SPECIES ACCOUNT: *Acipenser oxyrinchus (=oxyrhynchus) desotoi* (Atlantic sturgeon (Gulf subspecies))

Species Taxonomic and Listing Information

Listing Status: Threatened; 9/30/1991; Southeast Region (Region 4) (USFWS, 2015)

Physical Description

A large fish (sturgeon). The Length is 200 cm. (NatureServe, 2015). Gulf sturgeon are benthic fusiform fish with an extended snout, vertical mouth, five rows of scutes (bony plates surrounding the body), four barbels (slender, whiskerlike feelers anterior to the mouth used for touch and taste), and a heterocercal (upper lobe is longer than lower) caudal fin. Adults range from 6-8 feet in length and weigh up to 200 pounds; females grow larger than males (USFWS 2009b) (NMFS Chlorpyrifos, Diazinon, and Malathion BiOp, 2017)

Taxonomy

See Ong et al. (1996) for genetic data supporting the current subspecific designations. (NatureServe, 2015)

Historical Range

Once widely distributed throughout the coastal rivers of the northeastern Gulf of America, primarily from the Mississippi River east to Tampa Bay, including the states of Louisiana, Mississippi, Alabama, and Florida; sporadic occurrences are known as far west as Texas (Rio Grande) and in marine waters in Florida south to Florida Bay. (NatureServe, 2015)

Current Range

The present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida (USFWS 2003). (NatureServe, 2015). (NMFS Chlorpyrifos, Diazinon, and Malathion BiOp, 2017). The gulf sturgeon (Acipenser oxyrinchus desotoi) is one of two subspecies of the Atlantic Sturgeon (USFWS 1995). The gulf sturgeon is anadromous, and historically occurred in most river systems from the Mississippi river east to Tampa Bay, and in marine coastal/estuarine areas from the Central and Eastern Gulf of America south to Florida Bay (Wooley and Crateau 1985). The current range of the sub-species extends from Lake Pontchartrain in Louisiana east to the Suwannee river system in Florida. Within that range, seven major rivers are known to support reproducing populations: Pearl, Pascagoula, Escambia, Yellow, Choctawhatchee, Apalachicola, and Suwannee (USFWS 2009b) (NMFS Chlorpyrifos, Diazinon, and Malathion BiOp, 2017)

Distinct Population Segments Defined

Currently there is a lack of information to separate the species into population segments in accordance with the DPS policy across various genetic/geographic subdivisions. However, the Services believe that additional data from ongoing genetics analyses and tagging studies may allow us to determine whether Gulf sturgeon DPSs are identifiable. (USFWS, 2009)

Critical Habitat Designated

Yes; 3/19/2003.

Legal Description

On March 19, 2003, FWS and NMFS, collectively ‘‘the Services,’’ designated critical habitat for the Gulf sturgeon (Acipenser oxyrinchus desotoi), a threatened species listed under the Endangered Species Act of 1973, as amended (68 FR 13370 - 13495). The Services designated 14 geographic areas among the Gulf of America rivers and tributaries as critical habitat for the Gulf sturgeon. These 14 geographic areas (units) encompass approximately 2,783 river kilometers (rkm) (1,730 river miles (rmi)) and 6,042 square kilometers (km2) (2,333 square miles (mi2)) of estuarine and marine habitat.

Critical habitat identifies specific areas that are essential to the conservation of a listed species, and that may require special management considerations or protection. Section 7(a)(2) of the Act requires that each Federal agency shall, in consultation with and with the assistance of the Services, insure that any action authorized, funded or carried out by such agency is not likely to jeopardize the continued existence of an endangered or threatened species or result in the destruction or adverse modification of critical habitat. Section 4 of the Act requires the Services to consider economic and other relevant impacts of specifying any particular area as critical habitat.

Critical Habitat Designation

The critical habitat designation for Acipenser oxyrinchus (=oxyrhynchus) desotoi includes 14 units totaling 2,333 river miles in Louisiana, Mississippi, Florida, and Alabama.

Unit 1. Pearl River System in St. Tammany and Washington Parishes in Louisiana and Walthall, Hancock, Pearl River, Marion, Lawrence, Simpson, Copiah, Hinds, Rankin, and Pike Counties in Mississippi. Unit 1 includes the Pearl River main stem from the spillway of the Ross Barnett Dam, Hinds and Rankin Counties, Mississippi, downstream to where the main stem river drainage discharges at its mouth joining Lake Borgne, Little Lake, or The Rigolets in Hancock County, Mississippi, and St. Tammany Parish, Louisiana. It includes the main stems of the East Pearl River, West Pearl River, West Middle River, Holmes Bayou, Wilson Slough, downstream to where these main stem river drainages discharge at the mouths of Lake Borgne, Little Lake, or The Rigolets. Unit 1 also includes the Bogue Chitto River main stem, a tributary of the Pearl River, from Mississippi State Highway 570, Pike County, Mississippi, downstream to its confluence with the West Pearl River, St. Tammany Parish, Louisiana. The lateral extent of Unit 1 is the ordinary high water line on each bank of the associated rivers and shorelines. The majority of recent Gulf sturgeon sightings in the Pearl River drainage have occurred downstream of the Pools Bluff Sill on the Pearl River, near Bogalusa, Washington Parish, Louisiana, and downstream of the Bogue Chitto Sill on the Bogue Chitto River in St. Tammany Parish, Louisiana. Between 1992 and 1996, 257 Gulf sturgeon were captured from the Pearl River system (West Middle River, Bogue Chitto River, East Pearl River, and West Pearl River). The subpopulation was estimated at 292 fish, of which only 2 to 3 percent were adults (Morrow et al., 1998b). The annual mortality rate was calculated to be 25 percent. Preliminary results from captures between 1992 and 2001 suggest a stable subpopulation of 430 fish, with approximately 300 adults (Rogillio et al., 2002). These Pearl River distributaries are used for migration to spawning grounds, summer resting holes, and juvenile feeding. Gulf sturgeon have been captured in all of these distributaries and all are designated as critical habitat. The presence of juvenile Gulf sturgeon (1 to 4 years old) in the Pearl River system indicates successful spawning at some location in the Pearl River system. It is believed that the only suitable habitat for spawning for the Pearl River subpopulation of Gulf sturgeon occurs above the sills on the Pearl River and the Bogue Chitto River with access to these areas only during high flows (Morrow et al., 1996; and Morrow et al., 1998a). Bedrock and limestone outcropping that are typical of Gulf sturgeon spawning areas in other systems do not occur here. However, within the Pearl drainage, spawning areas likely include soapstone, hard clay, gravel and rubble areas, and undercut banks adjacent to these substrates (W. Slack, pers. comm. 2001). Although the Pools Bluff Sill blocks upstream movement on the Pearl River during periods of low water, potential spawning sites have been identified upstream of the sill at various locations between Monticello, Lawrence County, Mississippi, and the Ross Barnett Dam spillway, Hinds and Rankin Counties, Mississippi (F. Parauka, pers. comm. 2002). Gulf sturgeon have also been recently reported as far upstream as Jackson, Hinds County, Mississippi (Morrow et al., 1996; Lorio, 2000; and W. Slack, pers. comm. 2002). The Ross Barnett Dam upstream of Jackson prevents sturgeon movement further upstream at all flow conditions. Identified suitable spawning habitat, presence of juvenile fish, and documented adult captures support our inclusion of the Pearl River up to the spillway of the Ross Barnett Dam. The Bogue Chitto Sill, located on the Bogue Chitto River near its confluence with the Pearl River, also hinders movement of Gulf sturgeon upstream of the sill except during high water flows. Suitable spawning habitat occurs within the Bogue Chitto upriver of the sill (W. Slack, pers. comm. 2001; W. Granger, FWS, pers. comm. 2002; and F. Parauka, pers. comm. 2002) and juvenile, adult and subadult Gulf sturgeon have been documented on the Bogue Chitto River as far upstream as one mile north of Quinn Bridge (Mississippi State Highway 44), McComb, Pike County, Mississippi (W. Slack pers. comm. 2001; D. Oge, Louisiana Department of Environmental Quality, pers. comm. 2002; and F. Parauka, pers. comm. 2002). We, therefore, have designated as critical habitat the main stem of the Bogue Chitto River upstream of Quinn Bridge (Mississippi State Highway 44) to Mississippi State Highway 570 for ease of identification.

Unit 2. Pascagoula River System in Forrest, Perry, Greene, George, Jackson, Clarke, Jones, and Wayne Counties, Mississippi. Unit 2 includes all of the Pascagoula River main stem and its distributaries, portions of the Bouie, Leaf, and Chickasawhay tributaries, and all of the Big Black Creek tributary. It includes the Bouie River main stem beginning on the southern-most road crossing of Interstate 59, Forrest County, Mississippi, downstream to its confluence with the Leaf River, Forrest County, Mississippi. The Leaf River main stem beginning from Mississippi State Highway 588, Jones County, Mississippi, downstream to its confluence with the Chickasawhay River, George County, Mississippi is included. The main stem of the Chickasawhay River from the mouth of Oaky Creek, Clarke County, Mississippi, downstream to its confluence with the Leaf River, George County, Mississippi is included. Unit 2 also includes Big Black Creek main stem from its confluence with Black and Red Creeks, Jackson County, Mississippi, to its confluence with the Pascagoula River, Jackson County, Mississippi. All of the main stem of the Pascagoula River from its confluence with the Leaf and Chickasawhay Rivers, George County, Mississippi, to the discharge of the East and West Pascagoula Rivers into Pascagoula Bay, Jackson County, Mississippi, is included. The lateral extent of Unit 2 is the ordinary high water line on each bank of the associated rivers and shorelines. Subpopulation estimates, calculated from sturgeon captures in 1999 and 2000 in the summer holding areas on the Pascagoula River, range between 162 and 216 individuals (Heise et al., 1999a; and Ross et al., 2001b). Due to the sampling technique, these estimates are based primarily on large fish and do not account for juvenile or subadult fish (S. Ross, USM, pers. comm. 2001). Gulf sturgeon spawning on the Bouie River was confirmed via egg collection in 1999 (Slack et al., 1999; and Heise et al., 1999a). This is the only confirmed spawning area in the Pascagoula River drainage. Downstream, the Bouie River is sometimes used as a summer holding area (Ross et al., 2001b). Gulf sturgeon have been documented using the area above the known spawning habitat approximately 0.80 rkm (0.50 rmi) north of Glendale Road (Reynolds, 1993; and W. Slack, pers. comm. 2002). Additional suitable spawning habitat has been identified in this upstream reach (F. Parauka, pers. comm. 2002), and since Gulf sturgeon have rarely been documented upstream of spawning grounds, the Service has included the 4.8 rkm (3 rmi) of river reach upstream of the confirmed spawning grounds. For ease of identification, the Service has stopped on the southern-most road crossing of Interstate 59, where it crosses the Bouie River. Confirmed use for spawning and use as a summer holding area support the inclusion of the Bouie River as critical habitat. Documented sightings of Gulf sturgeon and identified suitable spawning habitat upstream to Mississippi State Highway 588 (Reynolds, 1993; W. Slack, pers. comm. 2002; and F. Parauka, pers. comm. 2002), confirmed use as a migration corridor, and confirmed use by juvenile Gulf sturgeon (W. Slack, pers. comm. 2002) support the inclusion of the Leaf River as critical habitat. Documented sightings of Gulf sturgeon using the Chickasawhay River (Miranda and Jackson, 1987; Reynolds, 1993; and Ross et al., 2001b) upstream to Quitman (Ross et al., 2001b), and the presence of apparently suitable spawning habitat at Quitman (F. Parauka, pers. comm. 2002), support the inclusion of this river reach as critical habitat for spawning, migration, and juvenile feeding. The Service has included the suitable spawning habitat located within 0.8 rkm (0.5 rmi) upstream of Mississippi State Road 512 and have extended the designation 9 rkm (5.5 rmi) upstream to the confluence with Oaky Creek for ease of identification. Gulf sturgeon use the West and East distributaries of the Pascagoula River during spring and fall migrations (Ross et al., 2001b). Summer resting areas have been consistently documented on Big Black Creek and on the Pascagoula River (Ross et al., 2001a and b). Confirmed use for migration and/or summer resting areas and probable feeding use by juveniles support our inclusion of these river reaches.

Unit 3. Escambia River System in Santa Rosa and Escambia Counties, Florida and Escambia, Conecuh, and Covington Counties, Alabama. Unit 3 includes the Conecuh River main stem beginning just downstream of the spillway of Point A Dam, Covington County, Alabama, downstream to the Florida State line, where its name changes to the Escambia River, Escambia County, Alabama, and Escambia and Santa Rosa Counties, Florida. It includes the entire main stem of the Escambia River downstream to its discharge into Escambia Bay and Macky Bay, Escambia and Santa Rosa Counties, Florida. All of the distributaries of the Escambia River including White River, Little White River, Simpson River, and Dead River, Santa Rosa County, Florida are included. The Sepulga River main stem from Alabama County Road 42, Conecuh and Escambia Counties, Alabama, downstream to its confluence with the Conecuh River, Escambia County, Alabama, is also included. The lateral extent of Unit 3 is the ordinary high water line on each bank of the associated lakes, rivers and shorelines. Sufficient data are not yet available to estimate historic or current subpopulation size of the Escambia River drainage subpopulation. Collection and tagging of Gulf sturgeon, monitoring, and eventual subpopulation estimates are in the initial phases on the Escambia River in Florida and the Conecuh River in Alabama. Suitable spawning habitat (Parauka and Giorgianni, 2002) and a reported larval sighting (N. Craft, Florida Department of Environmental Protection (FDEP), pers. comm. 2001), just below the Point A Dam (221 rkm (137 rmi)) on the Conecuh River support inclusion of critical habitat upstream to the Point A Dam. The Point A Dam prevents sturgeon movement further upstream at all flow conditions. In addition, spawning has been confirmed between rkm 161 and 170 (rmi 100 and 105.6) (Craft et al., 2001) on the Conecuh River. The use of the river main stem for spawning, adult resting areas, juvenile feeding and resting, and the use for migration to these sites supports our inclusion of the Escambia/Conecuh River main stem as critical habitat for the Escambia River subpopulation of Gulf sturgeon. Historic sightings reported from the 1910s and 1920s, and as recently as 1991, have been documented in Escambia County, Alabama, on the Sepulga River (Reynolds, 1993). Estes et al. (1991) describe the Sepulga as having smooth rock walls, and long pools with stretches of rocky shoals and sandbars. The Service included the Sepulga River reach upstream to Alabama County Road 42, Escambia County, Alabama, because it has suitable spawning habitat and documented sightings. The Service believes it is most likely that Gulf sturgeon use the Escambia River main stem and all the distributaries for exiting and entering the Escambia/ Conecuh River. Gulf sturgeon have been documented to use distributaries near the river mouth within other systems (e.g., Suwannee, Pearl, and Pascagoula River systems) for migration into and out of riverine habitat. We, therefore, have included all distributaries on the Escambia River system (i.e., White River, Little White River, Simpson River, and Dead River) in Unit 3.

Unit 4. Yellow River System in Santa Rosa and Okaloosa Counties, Florida and Covington County, Alabama. Unit 4 includes the Yellow River main stem from Alabama State Highway 55, Covington County, Alabama, downstream to its discharge at Blackwater Bay, Santa Rosa County, Florida. All Yellow River distributaries (including Weaver River and Skim Lake) discharging into Blackwater Bay are included. The Shoal River main stem, a Yellow River tributary, from Florida Highway 85, Okaloosa County, Florida, to its confluence with the Yellow River, is included. The Blackwater River from its confluence with Big Coldwater Creek, Santa Rosa County, Florida, downstream to its discharge into Blackwater Bay is included. Wright Basin and Cooper Basin, Santa Rosa County, on the Blackwater River are included. The lateral extent of Unit 4 is the ordinary high water line on each bank of the associated lakes, rivers and shorelines. The USGS conducted a subpopulation study in the Yellow River system during the spring (May to July) and fall (October) of 2001. Based on the capture of 98 fish in the spring and the capture/ recapture of 94 fish that fall, the USGS estimated the subpopulation to consist of 580 Gulf sturgeon of 1 m (3.3 ft) or greater in size (M. Randall, USGS, pers. comm. 2001). This estimate excludes fish younger than 3 to 4 years of age. Five distinct limestone outcrops have been documented as possible spawning sites on the Yellow River, between rkm 43 and 134 (rmi 26.7 and 83.3) (Parauka and Giorgianni, 2002). Several sites consist of brittle marl and limestone, and others of porous limestone. The lowest downstream site (rkm 43 (rmi 26.7)) is a primitive rock revetment, a manmade structure with a fair amount of rock substrate (Craft et al., 2001). In recent years, biologists working for the State of Alabama have observed youngof-the-year Gulf sturgeon near limestone outcrops 3.2 km (2 mi) south of Alabama State Highway 55 (136 rkm (84 rmi)) (Craft et al., 2001), which confirms that reproduction is occurring within this subpopulation. The river upstream of Alabama State Highway 55 is shallow, sandy, and creek-like and, therefore, not believed suitable for spawning (M. Randall, pers. comm. 2001; F. Parauka, pers. comm. 2001; and G. Morgan, Conecuh National Forest, pers. comm. 2001). Preliminary surveys located four potential summer resting reas on the Yellow River main stem (Craft et al., 2001). Recent fish captures and the confirmation of spawning at the furthest upstream spawning habitat location near Alabama State Highway 55 support our inclusion of the Yellow River main stem to Alabama State Highway 55 (136 rkm (84 rmi)) as critical habitat for the Yellow River subpopulation of Gulf sturgeon. The inclusion of the Shoal River, from the Yellow River confluence upstream to the Florida Highway 85 bridge (13 rkm (8 rmi)), is supported as critical habitat because it is a confirmed summer resting area (Lorio 2000). The potential for distributaries Weaver River and Skim Lake to be used for migration to and from the Yellow River system (Craft et al., 2001) supports their inclusion as critical habitat. The current and historic use of deep holes by Gulf sturgeon on the Blackwater River main stem and between Wright Basin and Cooper Basin demonstrate the importance of this area for summer resting and staging (Reynolds, 1993; and Craft et al., 2001) and support its inclusion as critical habitat for the Yellow River subpopulation.

Unit 5. Choctawhatchee River System in Holmes, Washington, and Walton Counties, Florida and Dale, Coffee, Geneva, and Houston Counties, Alabama. Unit 5 includes the Choctawhatchee River main stem from its confluence with the west and east fork of the Choctawhatchee River, Dale County, Alabama, downstream to its discharge at Choctawhatchee Bay, Walton County, Florida. The distributaries discharging into Choctawhatchee Bay known as Mitchell River, Indian River, Cypress River, and Bells Leg are included. The Boynton Cutoff, Washington County, Florida, which joins the Choctawhatchee River main stem, and Holmes Creek, Washington County, Florida, are included. The section of Holmes Creek from Boynton Cutoff to the mouth of Holmes Creek, Washington County, Florida, is included. The Pea River main stem, a Choctawhatchee River tributary, from the Elba Dam, Coffee County, Alabama, to its confluence with the Choctawhatchee River, Geneva County, Alabama, is included. The lateral extent of Unit 5 is the ordinary high water line on each bank of the associated rivers and shorelines. Preliminary estimates of the size of the Gulf sturgeon subpopulation in the Choctawhatchee River system are 2,000 to 3,000 fish over 61 cm (24 inches (in)) total length (F. Parauka, pers. comm. 2001). Biologists have located Gulf sturgeon within 0.8 rkm (0.5 rmi) downstream of the Elba Dam, Coffee County, Alabama, on the Pea River (Lorio, 2000) and have identified suitable spawning habitat from the Elba Dam to the Pea River mouth (Parauka and Giorgianni, 2002; and Hightower et al., in press). The Elba Dam prevents sturgeon movement further upstream at all flow conditions. This river reach has one confirmed spawning site, and Gulf sturgeon often use the lower reach for summer resting (Fox et al., 2000; and Hightower et al., in press). Suitable spawning and resting habitat, confirmed spawning, and young-of-the-year and juvenile feeding (F. Parauka, pers. comm. 2001) support inclusion of the Pea River reach as critical habitat. Five spawning sites and seven resting areas have been identified on the Choctawhatchee River main stem between the river mouth (0 rkm (0 rmi)) and upstream to 150 rkm (93 rmi) (Hightower et al., in press). Biologists have identified suitable spawning habitat (limestone outcrops) periodically between 135 rkm (84 rmi) to the confluence of the West Fork Choctawhatchee River and East Fork Choctawhatchee River (224 rkm (139 rmi)) (Parauka and Giorgianni, 2000; H. Blalock-Herod, FWS, pers. comm. 2002; and Hightower et al., in press). Fox et al. (2000) located a male at 150 rkm (93 rmi) and another male in spawning condition near Newton (214 rkm (133 rmi)) on the Choctawhatchee River, 8 rkm (5 rmi) downstream of the confluence of the West Fork Choctawhatchee River and East Fork Choctawhatchee River. Since Gulf sturgeon rarely occur upstream of spawning grounds, the Service has included up to the confluence of West Fork Choctawhatchee River and East Fork Choctawhatchee River for ease of identification and with the probability of unconfirmed spawning grounds. Suitable habitat, confirmed spawning, and young-of-the-year and juvenile feeding support the inclusion of the Choctawhatchee River main stem as critical habitat. No sturgeon have been documented within Holmes Creek, except for the section that connects the Choctawhatchee River and Boynton Cutoff, north and south. The Service has included this river section of Holmes Creek because it acts as part of the Choctawhatchee River main stem. In 1994, Gulf sturgeon were captured during March and April at the mouths of Indian River, Cypress River, and Bells Leg, indicating that sturgeon probably use these distributaries as migratory corridors to and from the Choctawhatchee River main stem. All distributaries, including the Indian River, Cypress River, Bells Leg, and Mitchell River, are included as critical habitat.

Unit 6. Apalachicola River System in Franklin, Gulf, Liberty, Calhoun, Jackson, and Gadsen Counties, Florida. Unit 6 includes the Apalachicola River mainstem, beginning from the Jim Woodruff Lock and Dam, Gadsden and Jackson Counties, Florida, downstream to its discharge at East Bay or Apalachicola Bay, Franklin County, Florida. All Apalachicola River distributaries, including the East River, Little St. Marks River, St. Marks River, Franklin County, Florida, to their discharge into East Bay and/or Apalachicola Bay are included. The entire main stem of the Brothers River, Franklin and Gulf Counties, Florida, a tributary of the Apalachicola River, is included. The lateral extent of Unit 6 is the ordinary high water line on each bank of the associated rivers and shorelines. Based on mark/recapture studies conducted in 1998 and 1999 in the Apalachicola River downstream of Jim Woodruff Lock and Dam, the summer subpopulation of subadult and adult Gulf sturgeon was estimated to be between 270 and 321 individuals (FWS, 1998; and FWS, 1999). Seventy-one sturgeon were collected in the upper Brothers River, upstream of the Brickyard Cutoff and downstream of Bearman Creek between June and September 1999 (FWS, 1999; and Lorio, 2000). Gulf sturgeon captured on the Brothers River have not been included in the Apalachicola River subpopulation size estimate although they are believed to be part of the subpopulation. The Gulf sturgeon became restricted to the portion of the Apalachicola River downstream of the Jim Woodruff Lock and Dam upon the construction of the dam in the 1950s. Wooley et al. (1982) documented the capture of two Gulf sturgeon larvae on the Apalachicola River just downstream of the Jim Woodruff Lock and Dam, thereby confirming successful spawning up to the dam. Resting aggregations are often seen at the base of the dam. Seven potential spawning sites have been identified in the upper Apalachicola River between Highway 20 and the Jim Woodruff Lock and Dam (120 to 171 km (76 to 106 rmi)) (Parauka and Giorgianni, 2002). Suitable spawning and resting habitat, confirmed spawning, and young-of-the-year and juvenile feeding support inclusion of the Apalachicola River as critical habitat. The entire main stem of the Brothers River, a major tributary of the Apalachicola River, is also included as critical habitat. Spawning has not been documented within this tributary, but an important resting area is located in the uppermost section of the Brothers River between Brickyard Cutoff and Bearman Creek (FWS, 1999; and Lorio, 2000). Sturgeon use the lower Brothers River as a resting and possible osmoregulation area (staging) before migrating into the estuarine and marine habitats for winter feeding (Wooley and Crateau, 1985). The Apalachicola River distributaries, including the East River, St. Marks River and Little St. Marks River, are included, based on information derived from other systems. Gulf sturgeon tend to use more than just the main stem for migration into and out of the river systems (e.g., Suwannee, Choctawhatchee, and Pearl Rivers).

Unit 7. Suwannee River System in Hamilton, Suwannee, Madison, Lafayette, Gilchrist, Levy, Dixie, and Columbia Counties, Florida. Unit 7 includes the Suwannee River main stem, beginning from its confluence with Long Branch Creek, Hamilton County, Florida, downstream to the mouth of the Suwannee River. It includes all the Suwannee River distributaries, including the East Pass, West Pass, Wadley Pass, and Alligator Pass, Dixie and Levy Counties, Florida, to their discharge into the Suwannee Sound or the Gulf of America. The Withlacoochee River main stem from Florida State Road 6, Madison and Hamilton Counties, Florida, to its confluence with the Suwannee River is included. The lateral extent of Unit 7 is the ordinary high water line on each bank of the associated rivers and shorelines. The Suwannee River supports the largest Gulf sturgeon subpopulation among the coastal rivers of the Gulf of America (Huff, 1975; and Gilbert, 1992). Sulak and Clugston (1999) reported 5,344 uniquely tagged Suwannee River sturgeons from 1986 to 1998. Multiple models using various age classes have been used to estimate the subpopulation size of Gulf sturgeon on the Suwannee River system. Chapman et al. (1997) estimated the subpopulation at 3,152 fish greater than age 6. Sulak and Clugston's (1999) estimate was 7,650 individuals greater than 61 cm (24 in) total length and older than age 2. Pine and Allen (2001) estimated the Suwannee River subpopulation at 5,500 individuals age 2 to 25. Based on intensive egg sampling efforts conducted between 1993 and 1998, Sulak and Clugston

(1999) estimated that 30 to 90 female fish spawn per year. Marchant and Shutters (1996) collected two Gulf sturgeon eggs from the Suwannee River in April 1993. These were the first Gulf sturgeon eggs collected in the wild. Between 1993 and 1998, three spawning sites were confirmed with the collection of Gulf sturgeon eggs on artificial substrate samplers (Marchant and Shutters, 1996; and Sulak and Clugston, 1999). Youngof-the-year have been documented using the river between rkm 10 to the confluence with Roaring Creek at approximately rkm 285 (177 rmi) on the Suwannee River main stem (Carr et al., 1996a; Sulak and Clugston, 1999; K. Sulak, pers. comm. 2002; and J. Clugston, pers. comm. 2002). It is believed that the farthest upstream that sturgeon spawn during high water is Big Shoals, near White Springs, Hamilton and Columbia Counties, Florida, but adult sturgeon are probably unable to move upstream of Big Shoals (Huff, 1975; K. Sulak, pers. comm. 2002; and M. Randall, pers. comm. 2002). Suitable spawning habitat has been identified upstream to Big Shoals (Huff, 1975; H. Blalock-Herod, pers. comm. 2002). Foster and Clugston (1997) located five major resting areas throughout the Suwannee River. A deep river bend and a shallow sandy section were characteristic features of the resting areas (Foster and Clugston, 1997). Confirmed use for spawning, identified and probable spawning habitat upstream to Big Shoals, young-of-year and juvenile feeding, and summer resting support the inclusion of the Suwannee River as critical habitat. For ease of identification, the Suwannee River has been included in the unit upstream of Big Shoals 0.8 rkm (0.5 rmi) to its confluence with Long Branch Creek. Adult Gulf sturgeon sightings and suitable spawning habitat on the lower Withlacoochee River near Florida State Road 141, Hamilton and Madison Counties, Florida, support the inclusion of this area as critical habitat. The Service has included shoals (5 rkm (3 rmi)) located just upstream of where sturgeon have been observed as possible spawning habitat, and have stopped at Florida State Road 6 (14 rkm (9 rmi)), upstream from the shoals, for ease of identification. The Suwannee River branches near its mouth into the East Pass and West Pass. Gulf sturgeon adults use the East Pass and West Pass for emigration and immigration (Mason and Clugston, 1993; and Edwards et al., in prep.). The West pass is divided into two primary channels—Wadley Pass, connected to the Gulf of America by a straight dredged channel across the northern portion of the Sound, and Alligator Pass, used by juveniles (Huff, 1975), connected to the Gulf of America by an undredged, natural channel. Confirmed use of the East Pass, West Pass, and Alligator Pass, and probable use of the Wadley Pass by adult and juvenile Gulf sturgeon for migration and feeding support the inclusion of all distributaries of the Suwannee River as critical habitat.

Unit 8. Lake Pontchartrain, Lake St. Catherine, The Rigolets, Little Lake, Lake Borgne, and Mississippi Sound in Jefferson, Orleans, St. Tammany, and St. Bernard Parish, Louisiana, Hancock, Jackson, and Harrison Counties in Mississippi, and in Mobile County, Alabama. Unit 8 encompasses Lake Pontchartrain east of the Lake Pontchartrain Causeway, all of Little Lake, The Rigolets, Lake St. Catherine, Lake Borgne, including Heron Bay, and the Mississippi Sound. Critical habitat follows the shorelines around the perimeters of each included lake. The Mississippi Sound includes adjacent open bays including Pascagoula Bay, Point aux Chenes Bay, Grand Bay, Sandy Bay, and barrier island passes, including Ship Island Pass, Dog Keys Pass, Horn Island Pass, and Petit Bois Pass. The northern boundary of the Mississippi Sound is the shoreline of the mainland between Heron Bay Point, Mississippi and Point aux Pins, Alabama. Critical habitat excludes St. Louis Bay, north of the railroad bridge across its mouth; Biloxi Bay, north of the U.S. Highway 90 bridge; and Back Bay of Biloxi. The southern boundary follows along the broken shoreline of Lake Borgne created by low swamp islands from Malheureux Point to Isle au Pitre. From the northeast point of Isle au Pitre, the boundary continues in a straight north-northeast line to the point 1 nautical mile (nm) (1.9 km) seaward of the western most extremity of Cat

Island (30°13'N, 89°10'W). The southern boundary continues 1 nm (1.9 km) offshore of the barrier islands and offshore of the 72 COLREGS lines at barrier island passes (defined at 33 CFR 80.815 ?)), (d) and (e)) to the eastern boundary. Between Cat Island and Ship Island there is no 72 COLREGS line. We, therefore, have defined that section of the unit southern boundary as 1 nm (1.9 km) offshore of a straight line drawn from the southern tip of Cat Island to the western tip of Ship Island. The eastern boundary is the line of longitude 88°18.8'W from its intersection with the shore (Point aux Pins) to its intersection with the southern boundary. The lateral extent of Unit 8 is the MHW line on each shoreline of the included water bodies or the entrance to rivers, bayous, and creeks. The Pearl River and its distributaries flow into The Rigolets, Little Lake, and Lake Borgne, the western extension of Mississippi Sound. The Rigolets connect Lake Pontchartrain and Lake St. Catherine with Little Lake and Lake Borgne. The Pascagoula River and its distributaries flow into Pascagoula Bay and Mississippi Sound. This unit provides juvenile, subadult and adult feeding, resting, and passage habitat for Gulf sturgeon from the Pascagoula and the Pearl River subpopulations. One or both of these subpopulations have been documented by tagging data, historic sightings, and incidental captures as using Pascagoula Bay, The Rigolets, the eastern half of Lake Pontchartrain, Little Lake, Lake St. Catherine, Lake Borgne, Mississippi Sound, within 1 nm (1.9 km) of the nearshore Gulf of America adjacent to the barrier islands and within the passes (Davis et al., 1970; Reynolds, 1993; Rogillio, 1993; Morrow et al., 1998a; Ross et al., 2001a; Rogillio et al., 2002; and F. Parauka, pers. comm. 2002). Substrate in these areas range from sand to silt, all of which contain known Gulf sturgeon prey items (Menzel, 1971; Abele and Kim, 1986; and American Fisheries Society, 1989). The Rigolets is an 11.3 km (7 mi) long and about 0.6 km (0.4 mi) wide passage connecting Lake Pontchartrain and Lake Borgne (U.S. Department of Commerce (USDOC), 2002). This brackish water area is used by adult Gulf sturgeon as a staging area for osmoregulation and for passage to and from wintering areas (Rogillio et al., 2002). Lake St. Catherine is a relatively shallow lake with depths averaging approximately 1.2 m (4 ft), connected to The Rigolets by Sawmill Pass. Bottom sediments in Sawmill Pass are primarily silt; Lake St. Catherine's are composed of silt and sand (Barrett, 1971). Incidental catches of Gulf sturgeon are documented from Lake St. Catherine and Sawmill Pass (Reynolds, 1993; and H. Rogillio, Louisiana Department of Wildlife and Fisheries, pers. comm. 2002). Based on the proximity of Little Lake, Lake St. Catherine, and Sawmill Pass to The Rigolets and Pearl River, the Service believes these areas are also used for staging and feeding and, therefore,the Service has included them with The Rigolets as critical habitat. Rogillio (1990) and Morrow et al. (1996) indicated that Lake Pontchartrain and Lake Borgne were used by Gulf sturgeon as wintering habitat, with most catches during late September through March. Lake Pontchartrain is 57.9 km (36 mi) long, 35.4 km (22 mi) wide at its widest point, and 3 to 4.9 m (10 to 16 ft) deep (USDOC, 2002). Morrow et al. (1996) documented Gulf sturgeon from the Pearl River system using Lake Pontchartrain (verified by tags) and summarized existing Gulf sturgeon records, which indicated greater use of the eastern half of Lake Pontchartrain. Although Rogillio et al. (2002) did not relocate any of their sonic tagged adult Gulf sturgeon in Lake Pontchartrain, the eastern part of this lake is believed to be an important winter habitat for juveniles and subadults (H. Rogillio, pers. comm. 2002). Furthermore, the Service believes that Gulf sturgeon forage in Lake Pontchartrain during the winter. The Lake Pontchartrain Causeway, twin toll highway bridges, extends 33.6 km (20.9 mi) across Lake Pontchartrain from Indian Beach on the south shore to Lewisburg and Mandeville on the north shore. Sediment data from Lake Pontchartrain indicate sediments have a greater sand content east of the causeway than west (Barrett, 1976). Most records of Gulf sturgeon from Lake Pontchartrain are located east of the causeway, with concentrations near Bayou Lacombe and Goose Point, both on the eastern north shore (Reynolds, 1993; and Morrow et al., 1996). While Gulf sturgeon have also been documented west of the causeway, generally near the mouths of small river systems (Davis, 1970), the Service has excluded the western portion of Lake Pontchartrain because the Service believes that the sturgeon utilizing this area are coming from western tributaries and not the Pearl River. Lake Pontchartrain connects by The Rigolets with Lake Borgne. Lake Borgne, the western extension of Mississippi Sound, is partly separated from Mississippi Sound by Grassy Island, Half Moon (Grand) Island and Le Petit Pass Island. Lake Borgne is approximately 14.3 km (23 mi) in length, 3 to 6 km (5 to 10 mi) in width and 1.8 to 3 m (6 to 10 ft) in depth (USDOC, 2002). Most of Lake Borgne sediment is clay and silt (Barrett, 1971). Many Gulf sturgeon were anecdotally reported as taken incidentally in shrimp trawls in Lake Borgne 0.6 to 1.2 km (1 to 2 mi) south of the Pearl River between August and October from the 1950s through the 1980s (Reynolds, 1993). There are twenty-two additional records of Gulf sturgeon in Lake Borgne (D. Walther, FWS, pers. comm. 2002). Known locations are spread out around the perimeter of the Lake, including at the mouth of The Rigolets, Violet Canal, Bayou Bienvenue, Polebe, Alligator Point, and at Half Moon Island (Reynolds, 1993). The Service has included all of Lake Borgne as critical habitat. The Mississippi Sound is separated from the Gulf of America by a chain of barrier islands, including Cat, Ship, Horn, and Petit Bois Islands. Natural depths of 3.7–5.5 m (12 to 18 ft) are found throughout the Sound and a channel 3.7 m (12 ft) deep has been dredged where necessary from Mobile Bay to New Orleans (USDOC, 2002). Incidental captures and recent studies confirm that both Pearl River and Pascagoula River adult Gulf sturgeon winter in the Mississippi Sound, particularly around barrier islands and barrier islands passes (Reynolds, 1993; Ross et al., 2001a; and Rogillio et al., 2002). Pascagoula Bay is adjacent to the Mississippi Sound. Gulf sturgeon exiting the Pascagoula River move both east and west, with telemetry locations as far east as Dauphin Island and as far west as Cat Island and the entrance to Lake Pontchartrain, Louisiana (Ross et al., 2001a). Tagged Gulf sturgeon from the Pearl River subpopulation have been located between Cat Island, Ship Island, Horn Island, and east of Petit Bois Islands to the Alabama State line (Rogillio et al., 2002). Gulf sturgeon have also been documented within 1 nm (1.9 km) off the barrier islands of Mississippi Sound. Therefore, the Service included 1 nm (1.9 km) offshore of the barrier islands of Mississippi Sound. Habitat used by Gulf sturgeon in the vicinity of the barrier islands is 1.9 to 5.9 m (6.2 to 19.4 ft) deep (average 4.2 m (13.8 ft)), with clean sand substrata (Heise et al., 1999b; Ross et al., 2001a; and Rogillio et al., 2002). Preliminary data from substrate samples taken in the barrier island areas indicate that all samples contained lancelets (Ross et al., 2001a). Inshore locations where Gulf sturgeon were located (Deer Island, Round Island) were 1.9 to 2.8 m (6.2 to 9.2 ft) deep and all had mud (mostly silt and clay) substrata (Heise et al., 1999b), typical of substrates supporting known Gulf sturgeon prey.

Unit 9. Pensacola Bay System in Escambia and Santa Rosa Counties, Florida. Unit 9 includes Pensacola Bay and its adjacent main bays and coves. These include Big Lagoon, Escambia Bay, East Bay, Blackwater Bay, Bayou Grande, Macky Bay, Saultsmar Cove, Bass Hole Cove, and Catfish Basin. All other bays, bayous, creeks, and rivers are excluded at their mouths. The western boundary is the Florida State Highway 292 Bridge crossing Big Lagoon to Perdido Key. The southern boundary is the 72 COLREGS line between Perdido Key and Santa Rosa Island (defined at 33 CFR 80.810 (g)). The eastern boundary is the Florida State Highway 399 Bridge at Gulf Breeze, Florida. The lateral extent of unit 9 is the MHW line on each shoreline of the included waterbodies. The Pensacola Bay system includes five interconnected bays, including Escambia Bay, Pensacola Bay, Blackwater Bay, East Bay, and the Santa Rosa Sound. The Santa Rosa Sound is addressed separately in unit 10. The Escambia River and its distributaries (Little White River, Dead River, and Simpson River) empty into Escambia Bay, including Bass Hole Cove, Saultsmar Cove, and Macky Bay. The Yellow River empties into Blackwater Bay. The entire system discharges into the Gulf of America, primarily through a narrow pass at the mouth of Pensacola Bay. The Pensacola Bay system provides winter feeding and migration habitat for Gulf sturgeon from the Escambia River and Yellow River subpopulations. Over the past four years, FDEP researchers have conducted tracking studies in the Pensacola Bay system to observe Gulf sturgeon winter migrations. They have identified specific areas in the bays where Escambia River and Yellow River Gulf sturgeon collect, or migrate through, during the fall and winter season. These studies also identified two main habitat types where Gulf sturgeon concentrate during winter months. Movement is generally along the shoreline area of Pensacola Bay. Gulf sturgeon showed a preference for several areas in the bay, including Redfish Point, Fort Dickens, and Escribano Point, near Catfish Basin (FWS, 1998; and Craft et al., 2001). Sandy shoal areas, located along the south and east side of Garcon Point, south shore of East Bay (Redfish Point area) and near Fair Point, appear to be commonly used, especially in the fall and early spring. During midwinter, sturgeon are commonly found in deep holes located north of the barrier island at Ft. Pickens, south of the Pensacola Naval Air Station, and at the entrance of Pensacola Pass. The depth in these areas ranges from 6 to 12.1 m (20 to 40 ft). Other areas where tagged fish were frequently located include Escribano Point, near Catfish Basin, and the mouth of the Yellow River. Previous incidental captures of Gulf sturgeon have been recorded in Pensacola Bay, Big Lagoon, and Bayou Grande (Reynolds, 1993; and Lorio, 2000).

Unit 10. Santa Rosa Sound in Escambia, Santa Rosa, and Okaloosa Counties, Florida. Unit 10 includes the Santa Rosa Sound, bounded on the west by the Florida State Highway 399 bridge in Gulf Breeze, Florida and the east by U.S. Highway 98 bridge in Fort Walton Beach, Florida. The northern and southern boundaries of unit 10 are formed by the shorelines to the MHW line or by the entrance to rivers, bayous, and creeks. The Santa Rosa Sound is a lagoon between the mainland and Santa Rosa Island that connects Pensacola Bay in the west with Choctawhatchee Bay in the east. The Sound extends east to west approximately 57.9 km (35.9 mi) and varies in width between 0.32 and 3.5 km (0.2 to 2.2 mi) (FDEP, 1993). The Intracoastal Waterway transects the sound. The Santa Rosa Sound is designated as critical habitat because we believe it provides one continuous migratory pathway between Choctawhatchee Bay, Pensacola Bay, and the Gulf of America for feeding and genetic interchange. Within the last 3,000 years, periodic shoaling closed the opening of Choctawhatchee Bay to the Gulf of America. For many years, the Santa Rosa Sound provided the only way for Choctawhatchee River Gulf sturgeon to migrate to the Gulf of America (Wakeford, 2001). Recent locations of subadult and adult Gulf sturgeon within the Santa Rosa Sound confirm its present use by the Choctawhatchee River subpopulations (Fox et al., 2002; and F. Parauka, pers. comm. 2002). The Escambia and Yellow Rivers subpopulations may also use this area due to its close proximity. Gulf sturgeon have been located mid-channel and in shoreline areas in 2 to 5.2 m (6.6 to 17.1 ft) depths and sand substrate. The approximate length of the critical habitat unit is 52.8 km (33 miles). Bridges were chosen as the eastern and western boundaries for ease in identification. Any portion of the sound not included in this unit is captured by the adjacent critical habitat units.

Unit 11. Florida Nearshore Gulf of America Unit in Escambia, Santa Rosa, Okaloosa, Walton, Bay, and Gulf Counties in Florida. Unit 11 includes a portion of the Gulf of America as defined by the following boundaries. The western boundary is the line of longitude 87°20.0'W (approximately 1 nm (1.9 km) west of Pensacola Pass) from its intersection with the shore to its intersection with the southern boundary. The northern boundary is the MHW of the mainland shoreline and the 72 COLREGS lines at passes as defined at 30 CFR 80.810 (a– g). The southern boundary of the unit is 1 nm (1.9 km) offshore of the northern boundary; the eastern boundary is the line of longitude

85°17.0'W from its intersection with the shore (near Money Bayou between Cape San Blas and Indian Peninsula) to its intersection with the southern boundary. Unit 11 includes winter feeding and migration habitat for Gulf sturgeon from the Yellow River, Choctawhatchee River, and Apalachicola River subpopulations. Telemetry relocation data suggest that these subpopulations feed in nearshore Gulf of America waters between their natal river systems (Fox et al., 2002; and F. Parauka, pers. comm. 2002). Gulf sturgeon from the Choctawhatchee River subpopulation have been documented both east and west of Choctawhatchee Bay (Fox et al., 2002; and F. Parauka, pers. comm. 2002). During the winter of 2001–2002, personnel from both USGS and FWS attached pop-up satellite tags to 20 Gulf sturgeon (12 from the Suwannee River, 4 from the Choctawhatchee River, 2 from the Apalachicola River, and 2 from the Yellow River) to identify winter feeding areas in the Gulf of America. Due to a design flaw, errors in attachment, or sturgeon’s ability to successfully shed the tags, the tags failed to report reliable data with only two exceptions. One of the Choctawhatchee River-tagged Gulf sturgeon was located in Hogtown Bayou in Choctawhatchee Bay; however, this provided no new information as we already knew that some adult Gulf sturgeon overwinter in this bayou. The other operating tag had been attached to a Yellow River Gulf sturgeon. Manual tracking in the vicinity of that Yellow River Gulf sturgeon led to the relocation of another tagged Gulf sturgeon. As a result, tagged individuals from three different subpopulations (Choctawhatchee, Yellow, and Apalachicola Rivers) were relocated on multiple occasions in close proximity to one another, suggesting an important feeding area just offshore of Mexico Beach, Crooked Island East, and Crooked Island West over sand substrate. These data suggest that Gulf sturgeon from the Yellow River, Choctawhatchee River, and Apalachicola River remain within 1.6 km (1 mi) of the coastline between these river systems (F. Parauka, pers. comm. 2002). Examination of bathymetry data along the Gulf of America coastline between the Pensacola Bay and Apalachicola Bay reveals that depths of less than 6 m (19.7 ft), where Gulf sturgeon are generally found, are all contained within 1 nm (1.9 km) from shore. Gulf nearshore substrate contains unconsolidated, fine-medium grain sands which support crustaceans such as mole crabs, sand fleas, various amphipod species, and lancelets (Menzel, 1971; Abele and Kim, 1986; and American Fisheries Society, 1989). Based on movement patterns, it appears these Gulf sturgeon were feeding in the nearshore Gulf of America on route to their natal rivers. Given this information, the Service has included the nearshore (up to 1 nm (1.9 km)) Gulf of America waters in this unit between Pensacola and Apalachicola Bays.

Unit 12. Choctawhatchee Bay in Okaloosa and Walton Counties, Florida. Unit 12 includes the main body of Choctawhatchee Bay, Hogtown Bayou, Jolly Bay, Bunker Cove, and Grassy Cove. All other bayous, creeks, and rivers are excluded at their mouths/ entrances. The western unit boundary is the U.S. Highway 98 bridge at Fort Walton Beach, Florida; the southern boundary is the 72 COLREGS line across East (Destin) Pass as defined at 33 CFR 80.810 (f). The lateral extent of unit 12 is the MHW line on each shoreline of the included water bodies. Choctawhatchee Bay provides important habitat for maintaining the health of subadult and adult Gulf sturgeon as evidenced by a large number of Gulf sturgeon overwintering in the system (FWS, 1997; FWS 1998; and Parauka et al., in press). The Choctawhatchee Bay offers a feeding area for both subadults and adults (FWS, 1998; and Fox et al., 2002). Tagged subadults showed a preference for shoreline habitats which are predominated by sandy substrates, low salinity and water depths less than 3 m (10 ft) (FWS, 1997; FWS, 1998; and Parauka et al., in press). Most adult Gulf sturgeon were located in shallow water (2 to 4 m (6.6 to 13.1 ft)) with predominantly (greater than 80 percent) sandy sediment (Fox et al., 2002). Ghost shrimp, a component of the sturgeon diet, are typically found in substrates ranging from sandy mud to organic silty sand (Felder and Lovett, 1989), and their densities were greatest nearshore along the middle and eastern portions of the Choctawhatchee Bay (Heard et al., 2000), the area frequented by the Gulf sturgeon (Fox et al., 2002). The Service has included the deeper central portion of the Bay in unit 12 as critical habitat because the Gulf sturgeon are known to use the deeper bay waters for movement between the shoreline areas (Fox et al., 2002).

Unit 13. Apalachicola Bay in Gulf and Franklin County, Florida. Unit 13 includes the main body of Apalachicola Bay and its adjacent sounds, bays, and the nearshore waters of the Gulf of America. These consist of St. Vincent Sound, including Indian Lagoon; Apalachicola Bay including Horseshoe Cove and All Tides Cove; East Bay including Little Bay and Big Bay; and St George Sound, including Rattlesnake Cove and East Cove. Barrier Island passes (Indian Pass, West Pass, and East Pass) are also included. Sike’s Cut is excluded from the lighted buoys on the Gulf of America side to the day boards on the bay side. The southern unit boundary includes water extending into the Gulf of America 1 nm (1.9 km) from the MHW line of the barrier islands and from 72 COLREGS lines between the barrier islands (defined at 33 CFR 80.805 (e–h)); the western boundary is the line of longitude 85°17.0'W from its intersection with the shore (near Money Bayou between Cape San Blas and Indian Peninsula) to its intersection with the southern boundary. The eastern boundary of the unit is formed by a straight line drawn from the shoreline of Lanark Village at 29°53.1'N, 84°35.0'W to a point that is 1 nm (1.9 km) offshore from the northeastern extremity of Dog Island at 29°49.6’N, 84°33.2’W. The lateral extent of unit 13 is the MHW line on each shoreline of the included water bodies or the entrance of excluded rivers, bayous, and creeks. The Apalachicola River empties into Apalachicola Bay near Little Bay and Big Bay. The Apalachicola Bay system, a highly productive lagoon-and-barrierisland complex, consists of the bay proper, East Bay, St. George Sound, Indian Lagoon, and St. Vincent Sound (Wakeford, 2001). It is relatively shallow, averaging 2 to 3 m (6.6 to 9.8 ft) in depth (Livingston, 1980). The benthic habitat type most often found in Apalachicola Bay system is soft sediment, comprising approximately 70 percent of the estuarine area (Livingston, 1980). Its composition of sand, clay, and silt varies considerably depending on the location in the bay. The Apalachicola Bay connects with the Gulf of America through several passes, including Indian Pass, West Pass, East Pass, and Sike’s Cut, a man-made opening established in the mid 1950s (Odenkirk, 1989). Unit 13 provides winter feeding migration habitat for the Apalachicola River Gulf sturgeon subpopulation. Gulf sturgeon have been documented by sightings, incidental captures, and telemetry studies throughout Apalachicola Bay, East Bay, St. George Sound, St. Vincent Sound, and Indian Lagoon (Swift et al., 1977; Wooley and Crateau, 1985; Odenkirk, 1989; FWS, 2000; and F. Parauka, pers. comm. 2002). Gulf sturgeon have also been documented in Indian Pass, West Pass, East Pass, and just north of Dog Island (Wooley and Crateau, 1985; Odenkirk, 1989; FWS, 2000; and F. Parauka, pers. comm. 2002). Substantial weight gains and the presence of suitable habitat for prey items indicate that Gulf sturgeon are feeding while within these bodies of water (Wooley and Crateau, 1985; and Odenkirk, 1989). These areas are also used for accessing adjacent marine and estuarine feeding areas designated in unit 11. Gulf sturgeon are believed to migrate from Apalachicola Bay into the Gulf of America following prevailing currents and exiting primarily through the two most western passes (Indian and West) (Odenkirk, 1989). No Gulf sturgeon have been documented using Sike’s Cut, a man-made opening established in the 1950s bisecting Little St. George Island and St. George Island; therefore, Sike’s Cut is excluded from our designation. Tag return data from incidental captures and recent relocation data document Gulf sturgeon south of the Apalachicola barrier islands, generally within a mile of the shoreline (Odenkirk, 1989; and FWS, 2000). On June 8, 1992, a commercial shrimp fisherman provided anecdotal information that he and other shrimp fishermen, had caught hundreds of Gulf sturgeon, with estimated weights generally between 22.7 to 27.2 kg (50 to 60 lbs), in the same location, each spring (April, May, and June), for the past thirty years (1962 to 1992) (F. Parauka, pers. comm. 2002). The fishermen described the location as south of St. George Island, within a few hundred yards of the beach. He described the capture areas as being adjacent to a shoal extending approximately 3.2 km (2 mi) offshore. Examination of bathymetric data shows that there are several shoals in that general vicinity. Since the Service is unable to confirm the specific location of the area described by this fisherman, the Service is extending this critical habitat unit only 1 nm (1.9 km) offshore of the barrier islands bordering Apalachicola Bay and Cape San Blas, a distance for which we have supporting telemetry data. In doing so, the Service will capture some of the shallow shoals extending south of the barrier islands, which the Service believes provide important foraging substrate.

Unit 14. Suwannee Sound in Dixie and Levy Counties, Florida. Unit 14 includes Suwannee Sound and a portion of adjacent Gulf of America waters extending 9 nm from shore (16.7 km) out to the State territorial water boundary. Its northern boundary is formed by a straight line from the northern tip of Big Pine Island (at approximately 29°23'N, 83°12'W) to the Federal-State boundary at 29°17'N, 83°21'W; the southern boundary is formed by a straight line from the southern tip of Richards Island (at approximately 29°11'N, 83°04'W) to the Federal-State boundary at 29°04'N, 83°15'W. The lateral extent of unit 14 is the MHW line along the shorelines and the mouths of the Suwannee River (East and West Pass), its distributaries and other rivers, creeks, or water bodies. The Suwannee River system is unique among Gulf sturgeon river systems in that the river flows directly into the Suwannee Sound and Gulf of America without any intervening barrier islands. Suwannee Sound is a shallow (typically less than 2 m (6.6 ft)), estuarine basin, a little less than 10 nm (8 km) long and a little over 4 nm (8 km) wide at its widest point. It is enclosed on its seaward side by Suwannee Reef, an approximately 14.6 nm (27 km) long arc of oyster reefs and shoals (Edwards et al., in prep.). The bathymetry of waters off the coastline and north and south of Suwannee Sound is different from the waters adjacent to other systems. Shallow waters are not confined to the nearshore environment, and depths less than 6 m (19.7 ft) extend 9 to 10 mi (14.5 to 16.1 km) off the coastline. Telemetry data confirm that subadult and adult Gulf sturgeon leave the river during October and November and enter Suwannee Sound and the nearshore Gulf of America (Carr et al., 1996b; and Edwards et al., in prep.). Tracking data indicate that Gulf sturgeon move slowly and remained offshore of Suwannee Sound in nearby shallow (less than 6 m (19.7 ft)) marine/estuarine habitats for a period of two months, until at least mid or late December. Overall movement patterns are punctuated by periods of slow movement within small areas, suggesting foraging (Edwards et al., in prep.). Mason and Clugston (1993) found large, immigrating Suwannee River Gulf sturgeon fed on nearshore coastal shelf organisms lancelets (Branchiostoma caribaeum), brachiopods
(Glottida pyramida), unidentified pelagic shrimps, polychaetes, unidentified marine molluscs, starfish and sea cucumbers. Carr et al. (1996b) found that adult Gulf sturgeon feed primarily on brachiopods and ghost shrimp, before entering the river. The consumption of brachiopods as a primary Gulf sturgeon food source is currently being researched by the University of Florida. Numerous underwater beds containing brachiopods have recently been located in the Suwannee River estuary and adjacent areas in Suwannee Sound (D. Murie and D. Parkyn, pers. comm. 2002). Recent stomach content analyses using a non-lethal method of stomach pumping (lavaging) support that Gulf sturgeon from the Suwannee River subpopulation feed primarily on brachiopods, and to lesser amounts on ghost shrimp, amphipods, and worms prior to entering the river (D. Murie and D. Parkyn, pers. comm. 2002). Gulf sturgeon tracking and relocation data were used to delineate the boundaries of this critical habitat unit. In 1998, 18 out of 19 sonic-tagged Gulf sturgeon were consistently relocated and found to be concentrated in a relatively

small area (115 km 2 (44.4 mi 2)) offshore of Suwannee Sound (Edwards et al., in prep.). Specific locations within the concentration area were around Waldley Channel, West Gap, and Hedemon Reef. The farthest offshore area was Hedemon Reef, approximately 5 to 6 nm (9.3 to 11.1 km) from the Suwannee River opening. Previous telemetry data and tag recaptures documented Gulf sturgeon using Gulf of America waters as far out as 9 nm (16.7 km) (Sulak and Clugston, 1999; and Edwards et al., in prep.). More recently, on March 22, 2002, two Gulf sturgeon were observed jumping in the area of 29°14'N, 83°18'W, further substantiating the Gulf sturgeon's use of shallow State waters further offshore (greater than 6 nm (11.1 km)) (Harris, pers. comm. 2002). Benthic samples taken where the fish were jumping were comprised of fine sand substrate and lancelets. Although lancelets are recovered less frequently than brachiopods in the stomachs of Suwannee River Gulf sturgeon, this may be a result of quicker decomposition of lancelets during digestion compared to brachiopods. Our designation, therefore, includes waters out to 9 nm
(16.7 km) to encompass these areas that we believe are essential for the conservation of the Gulf sturgeon. The northern extent of the tracked sturgeon concentration area depicted in Edwards et al. (in prep.) corresponds approximately to the northern-most extremity of Big Pine Island. We, therefore, have chosen that easy-toidentify location for the northern limit of this critical habitat unit. The southern extent of the concentration area depicted in Edwards et al. (in prep.) corresponds approximately to Richards Island. In addition to the telemetry data, Gulf sturgeon sightings are frequently reported around Deer Island and Derrick Key (F. Chapman, UF, pers. comm. 2002). Derrick Key is approximately 1 m (1.6 km) offshore of Richards Island. Based on these data, the Service is designating the southernmost extremity of Richards Island for the southern limit of unit 14. Although Gulf sturgeon have been relocated both north and south of this critical habitat area (Reynolds, 1993; F. Chapman, pers. comm. 2002; and Edwards et al., in prep.), records are relatively rare and encompass approximately 643.7 km (400 mi) of coastline (from Charlotte Harbor to Apalachicola Bay). While Gulf sturgeon may congregate in additional shallow water areas or migrate throughout the entire area, without additional information the Service cannot include additional areas as critical habitat.

Critical Habitat for gulf sturgeon was established in 2003 68 FR 13370) and consists of 14 geographic units encompassing 2,783 river kilometers as well as 6,042 square kilometers of estuarine and marine habitat. PBFs considered essential for the conservation of Gulf Sturgeon are: ? Abundant food items, such as detritus, aquatic insects, worms, and/or molluscs, within riverine habitats for larval and juvenile life stages; and abundant prey items, such as amphipods, lancelets, polychaetes, gastropods, ghost shrimp, isopods, molluscs and/or crustaceans, within estuarine and marine habitats and substrates for subadult and adult life stages. ? Riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone, or hard clay; ? Riverine aggregation areas, also referred to as resting, holding, and staging areas, used by adult, subadult, and/or juveniles, generally, but not always, located in holes below normal riverbed depths, believed necessary for minimizing energy expenditures during fresh water residency and possibly for osmoregulatory functions; ? A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging, and for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larval staging; ? Water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; ? Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and ? Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g., an unobstructed river or a dammed river that still allows for passage) (NMFS Chlorpyrifos, Diazinon, and Malathion BiOp, 2017).

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements essential for the conservation of Gulf sturgeon are those habitat components that support feeding, resting, and sheltering, reproduction, migration, and physical features necessary for maintaining the natural processes that support these habitat components. The primary constituent elements include:

(i) Abundant prey items within riverine habitats for larval and juvenile life stages, and within estuarine and marine habitats and substrates for juvenile, subadult, and adult life stages;

(ii) Riverine spawning sites with substrates suitable for egg deposition and development, such as limestone outcrops and cut limestone banks, bedrock, large gravel or cobble beds, marl, soapstone or hard clay;

(iii) Riverine aggregation areas, also referred to as resting, holding, and staging areas, used by adult, subadult, and/or juveniles, generally, but not always, located in holes below normal riverbed depths, believed necessary for minimizing energy expenditures during fresh water residency and possibly for osmoregulatory functions;

(iv) A flow regime (i.e,. the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages in the riverine environment, including migration, breeding site selection, courtship, egg fertilization, resting, and staging; and necessary for maintaining spawning sites in suitable condition for egg attachment, egg sheltering, resting, and larvae staging;

(v) Water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;

(vi) Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and

(vii) Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g. a river unobstructed by any permanent structure, or a dammed river that still allows for passage).

Special Management Considerations or Protections

Gulf sturgeon is under the joint jurisdiction of the U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS). The FWS will maintain primary responsibility for recovery actions and NMFS will assist in and continue to fund recovery actions pertaining to estuarine and marine habitats. In riverine units, the FWS will be responsible for all consultations regarding Gulf sturgeon and critical habitat. In estuarine units, the Service will divide responsibility based on the action agency involved. The FWS will consult with the Department of Transportation, the Environmental Protection Agency, the U.S. Coast Guard, and the Federal

Emergency Management Agency. NMFS will consult with the Department of Defense, U.S. Army Corps of Engineers, Minerals Management Service and any other Federal agencies not mentioned here explicitly. In marine units, NMFS will be responsible for all consultations regarding Gulf sturgeon and critical habitat. Any Federal projects that extend into the jurisdiction of both the Services will be consulted on by the FWS with internal coordination with NMFS. Each agency will conduct its own intra-agency consultations as necessary.

Various activities in or adjacent to each of the critical habitat units described in this rule may affect one or more of the primary constituent elements that are found in the unit. For example, riverine spawning sites for Gulf sturgeon must be relatively sediment-free for successful egg development and may need best management practices implemented in the watershed upstream to prevent an excessive accumulation of sediment in these areas. None of the critical habitat units are presently under special management or protection provided by a legally operative plan or agreement for the conservation of the Gulf sturgeon. Therefore, the Service has determined that all units may require special management or protection.

Activities that may destroy or adversely modify critical habitat for the Gulf sturgeon, or that may be affected by such designation, include, but are not limited to the following actions when authorized, funded or carried out by a Federal agency: (1) Actions that would appreciably reduce the abundance of riverine prey for larval and juvenile sturgeon, or of estuarine and marine prey for juvenile and adult Gulf sturgeon, within a designated critical habitat unit, such as dredging; dredged material disposal; channelization; in-stream mining; and land uses that cause excessive turbidity or sedimentation. (2) Actions that would appreciably reduce the suitability of Gulf sturgeon spawning sites for egg deposition and development within a designated critical habitat unit, such as impoundment; hard-bottom removal for navigation channel deepening; dredged material disposal; in-stream mining; and land uses that cause excessive sedimentation. (3) Actions that would appreciably reduce the suitability of Gulf sturgeon riverine aggregation areas, also referred to as resting, holding, and staging areas, used by adult, subadult, and/or juveniles, believed necessary for minimizing energy expenditures and possibly for osmoregulatory functions, such as dredged material disposal upstream or directly within such areas; and other land uses that cause excessive sedimentation. (4) Actions that would alter the flow regime (the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) of a riverine critical habitat unit such that it is appreciably impaired for the purposes of Gulf sturgeon migration, resting, staging, breeding site selection, courtship, egg fertilization, egg deposition, and egg development, such as impoundment; water diversion; and dam operations. (5) Actions that would alter water quality within a designated critical habitat unit, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, such that it is appreciably impaired for normal Gulf sturgeon behavior, reproduction, growth, or viability, such as dredging; dredged material disposal; channelization; impoundment; instream mining; water diversion; dam operations; land uses that cause excessive turbidity; and release of chemicals, biological pollutants, or heated effluents into surface water or connected groundwater via point sources or dispersed non-point sources. (6) Actions that would alter sediment quality within a designated critical habitat unit such that it is appreciably impaired for normal Gulf sturgeon behavior, reproduction, growth, or viability, such as dredged material disposal; channelization; impoundment; in-stream mining; land uses that cause excessive sedimentation; and release of chemical or biological pollutants that accumulate in sediments. (7) Actions that would obstruct migratory pathways within and between adjacent riverine, estuarine, and marine critical habitat units, such as dams, dredging, point-source-pollutant discharges, and other physical or chemical alterations of channels and passes that restrict Gulf sturgeon movement.

Life History

Feeding Narrative

Adult: Feeds primarily on benthic invertebrates and small fishes as available (e.g., worms, crustaceans, aquatic insects, snails, sand lances). Feeding evidently occurs only during the winter and spring in offshore or estuarine waters (Cross 1992). Adults and immatures are piscivores and invertivores (NatureServe, 2015). Can (1983) found that on the average, marked Gulf sturgeon from the Suwannee River gained 30% of body weight in one year. He also noted that little or no growth was seen when recapture occurred during the same season and a little weight was lost by some (USFWS, 1995).

Reproduction Narrative

Adult: Takes at least 7-8 years to mature; females spawn at intervals of more than one year; see USFWS (2003) for further details. This species migrates to upper rivers in spring for spawning. Spawns in fresh water (sometimes tidal) usually over bottom of hard clay, rubble, gravel, or shell. May spawn in brackish water. Most spawn in natal river (NatureServe, 2015). Most subadult and adult Gulf sturgeon ascend coastal rivers from the Gulf of America from mid February through April when some adults are sexually mature and in ripe condition. Huff (1975) found that sexually mature females ranged in age from 8 to 17 years and sexually mature males from 7 to 21 years in the Suwannee River. Chapman et al. (1993) reported that three mature Gulf sturgeon had 458,080, 274,680, and 475,000 eggs and were estimated to have an average fecundity of 20,652 eggs/kg (9,366 eggs/lb.). Gulf sturgeon eggs are demersal and adhesive (Vladykov 1963; Huff 1975; Parauka et al., 1991; Chapman et al., 1993) (USFWS, 1995).

Geographic or Habitat Restraints or Barriers

Adult: Dams (USFWS, 1995)

Environmental Specificity

Adult: Broad (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (NatureServe, 2015)

Habitat Narrative

Adult: Primarily marine/estuarine in winter; migrates to upper rivers in spring for spawning; returns to sea/estuary in fall; some may remain near spawning areas. First two years are spent in riverine habitats. Dams create barriers to spawning habitats. See USFWS (2003) for many details (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: High (inferred from NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Migratory (NatureServe, 2015)

Dispersal

Adult: High (NatureServe, 2015)

Dispersal/Migration Narrative

Juvenile: Upon hatching from their eggs, gulf sturgeon larvae spend the first few days of life sheltered in interstitial spaces at the spawning site (Kynard and Parker 2004). At the onset of feeding, age-0 gulf sturgeon disperse and are often found on shallow sandbars and rippled sand shoals (<4 meters depth) (Sulak and Clugston 1998). Young-of-the-year spend 6-10 months slowing working their way downstream feeding on aquatic insects (e.g., mayflies and caddisflies), worms (oligochaetes), and bivalve molluscs, and arrive in estuaries and river mouths by mid-winter (Sulak and Clugston 1999) where they will spend their next 6 years developing. After spawning, adult gulf sturgeon migrate downstream to summer resting and holding areas in the mid to lower reaches of the rivers where they may hold until November (Wooley and Crateau 1985). While in freshwater adults lose a substantial amount of their weight, but regain it upon entering the estuaries. Sub adult and non-spawning adults also spend late spring through fall in these holding areas (Foster and Clugston 1997). By early December all adult and sub-adult gulf sturgeon return to the marine environment to forage on benthic (bottom dwelling) invertebrates along the shallow nearshore (2-4 meter depth), barrier island passes, and in unknown off-shore locations in the gulf (Carr et al. 1996; Fox et al. 2002; Huff 1975; Ross et al. 2009). Juvenile gulf sturgeon overwinter in estuaries, river mouths, and bays; juveniles do not enter the nearshore/offshore marine environments until around age 6 (Sulak and Clugston 1999). Gulf sturgeon show a high degree of river-specific fidelity (Rudd et al. 2014). Adult and sub-adult gulf sturgeon fast while in freshwater environments and are almost entirely dependent on the estuarine/marine environment for food (Gu et al. 2001; Wooley and Crateau 1985). Some juveniles (ages 1-6) will also fast in the freshwater summer holding areas, but the majority feed year round in the estuaries, river mouths, and bays (Sulak et al. 2009) (NMFS Chlorpyrifos, Diazinon, and Malathion BiOp, 2017).

Adult: Adults migrate between fresh water spawning areas and salt water nonspawning areas. Primarily marine/estuarine in winter; migrates to upper rivers in spring for spawning; returns to sea/estuary in fall; some may remain near spawning areas. Moves into the Suwanne River February-May (mainly late March-early April); may migrate as far as 140 miles upstream; subadults and adults return to the Gulf of America in late fall, while young generally stay in the river mouth in winter and spring (Cross 1992). See recovery plan (USFWS 1995) and USFWS (2003) for further information. This species is a local and distant migrant (NatureServe, 2015). Gulf sturgeon are long-lived, with some individuals reaching at least 42 years in age. Surveys in the Suwannee River suggest that a more common maximum age may be around 25 years (Sulak and Clugston 1999). Age at sexual maturity for females ranges from 8 to 17 years, and for males from 7 to 21 years (Huff 1975). In general, gulf sturgeon spawn up-river in spring, spend winter months in near-shore marine environments, and utilize pre- and post-spawn staging and nursery areas in the lower rivers and estuaries (Heise et al. 2005; Heise et al. 2004). There is some evidence of autumn spawning in the Suwannee River, however there is uncertainty as to whether this spawning is due to environmental conditions or represents a genetically distinct population (Randall and Sulak 2012). Gulf sturgeon spawn at intervals ranging from 3-5 years for females and 1-5 years for males (Fox et al. 2000; Smith 1985). The spring migration to up-river spawning sites begins in mid-February and continues through May. Fertilization is external;

females deposit their eggs in the upper reaches of and show preference for hard, clean substrate (e.g. bedrock covered in gravel and small cobble) (NMFS Chlorpyrifos, Diazinon, and Malathion BiOp, 2017).

Population Information and Trends

Population Trends:

Not available

Species Trends:

Stable (USFWS, 2009)

Number of Populations:

7 (USFWS, 2009)

Population Size:

2500 - 10,000 individuals (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Slow growth and late maturation limit the subspecies' ability to recover quickly from declines. The present range extends from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi east to the Suwannee River in Florida (USFWS 2003). The estimated population size is 2,500 to 10,000 individuals (NatureServe, 2015). NMFS currently considers the status of the Gulf sturgeon as stable. Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. (USFWS, 2009). The decline in the abundance of gulf sturgeon has been attributed to targeted fisheries in the late 19th and early 20th centuries, habitat loss associated with dams and sills, habitat degradation associated with dredging, de-snagging, and contamination by pesticides, heavy metals, and other industrial contaminants, and certain life history characteristics (e.g. slow growth and late maturation) (56 FR 49653). Effects of climate change (warmer water, sea level rise and higher salinity levels) could lead to accelerated changes in habitats utilized by Gulf sturgeon. The rate that climate change and corollary impacts are occurring may outpace the ability of the Gulf sturgeon to adapt given its limited geographic distribution and low dispersal rate. In general, gulf sturgeon populations in the eastern portion of the range appear to be stable or slightly increasing, while populations in the western portion are associated with lower abundances and higher uncertainty (USFWS 2009b) (NMFS Chlorpyrifos, Diazinon, and Malathion BiOp, 2017). Abundance: Currently, seven rivers are known to support reproducing populations of Gulf sturgeon. The most recent abundance estimates reported in the 5-Year Review (USFWS 2009b). Productivity / Population Growth Rate: Gulf sturgeon abundance trends are typically assessed on a riverine basis. In general, gulf sturgeon populations in the eastern portion of the range appear to be stable or slightly increasing, while populations in the western portion are associated with lower abundances and higher uncertainty (USFWS 2009b). Pine and Martell (2009) reported that, due to low recapture rates and sparse data, the population viability of gulf sturgeon is currently uncertain. Genetic Diversity: When grouped by genetic relatedness, five regional or river-specific stocks emerge: (1) Lake Pontchartrain and Pearl River; (2) Pascagoula River; (3) Escambia, Blackwater and Yellow

Rivers; (4) Choctawhatchee River; and (5) Apalachicola, Ochlocknee and Suwanee Rivers (Rudd et al. 2014; Stabile et al. 1996). Gene flow is low in Gulf sturgeon stocks, with each stock exchanging less than one mature female per generation (Waldman and Wirgin 1998) (NMFS Chlorpyrifos, Diazinon, and Malathion BiOp, 2017).

Threats and Stressors

Stressor: Destruction/modification of habitat: Damns (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Access to historic Gulf sturgeon spawning habitat continues to be blocked by existing dams and the ongoing operations of these dams also effect downstream habitat. Several new dams are being proposed that would increase these threats to the Gulf sturgeon and its habitat. Dams continue to impede access to upstream spawning areas, and continue to adversely affect downstream habitat including both spawning and foraging areas. All of the dams noted in the listing rule continue to block passage of Gulf sturgeon to historical spawning habitats and thus either reduce the amount of available spawning habitat or entirely impede access to it.

Stressor: Destruction/modification of habitat: Dredging (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Dredging and disposal to maintain navigation channels, and removal of sediments for beach renourishment occurs frequently and throughout the range of the Gulf sturgeon and within designated Gulf sturgeon habitat annually. This activity has, and continues to threaten the species and affect its designated critical habitat.Riverine, estuarine, and coastal navigation channels are often dredged to support commercial shipping and recreational boating. Dredging activities can pose significant impacts to aquatic ecosystems by: 1) direct removal/burial of organisms; 2) turbidity/siltation effects; 3) contaminant re-suspension; 4) noise/disturbance; 5) alterations to hydrodynamic regime and physical habitat; and 6) loss of riparian habitat (Chytalo 1996, Winger et al. 2000). Dredging operations may also destroy benthic feeding areas, disrupt spawning migrations, and re-suspend fine sediments causing siltation over required substrate in spawning habitat. Because Gulf sturgeon are benthic omnivores, the modification of the benthos affects the quality, quantity, and availability of prey.

Stressor: Destruction/modification of habitat: Point and non-point discharges (sediment and pollution)(USFWS 2009)
Exposure:
Response:
Consequence:
Narrative: Evaluations of water and sediment quality in Gulf Sturgeon habitat on the northern Gulf of America coast, have consistently shown elevated pollutant loading. This has been observed in both tidal coastal rivers of the type that the sturgeon use in the spring and summer (Hemming et al. 2006, 2008). Perhaps better understood is the widespread contamination throughout the overwintering feeding habitat of the Gulf sturgeon (Brim 1998, 2000, NWFWMD 1997, 1998, 2000, 2002, Hemming 2002, 2003a, 2003b, 2004, 2007). Although the specific effects of these widely varied pollutants on sturgeon in their various life stages is not clearly understood, there is

ample evidence to show potential deleterious effects to Gulf sturgeon and their habitat (USFWS, 2009). Deleterious effects include impacts to successful egg fertilization and egg and larval development as a result of changes in pH, calcium ion concentration, termperature, and dissolved oxygen. Critical habitat threats have been identified based on degraded habitat characteristics, such as erosion, riparian condition, presence of unpaved roads, and the presence of agriculture. The loss of habitat associated with pollution and contamination has been documented for sturgeon species worldwide (Verina and Peseridi 1979, Shagaeva et al. 1993, Barannikova et al. 1995). Specific impacts of pollution and contamination on sturgeon have been identified to include muscle atrophy, abnormality of gonad, sperm and egg development, morphogenesis of organs, tumors, and disruption of hormone production. Furthermore, pharmaceuticals and other endocrinologically active chemicals have been found in fresh and marine waters at effective concentrations (reviewed in Fent et al. 2006). These compounds enter the aquatic environment via wastewater treatment plants, agricultural facilities, and farm runoff (Folmar et al. 1996, Culp et al. 2000, Wildhaber et al. 2000, Wallin et al. 2002). These products are the source of both natural and synthetic substances including, but not limited to, polychlorinated biphenyls, phthalates, pesticides, heavy metals, alkylphenols, polycyclic aromatic hydrocarbons, 17ß-estradiol, 17a-ethinylestradiol, and bisphenol A. The impact of these exposures on Gulf sturgeon is unknown, but other species of fish are affected in rivers and streams. Settlement of these contaminants to the benthos may affect benthic foragers to a greater extent than pelagic foragers due to foraging strategies (Geldreich and Clarke 1966). Several characteristics of the Gulf sturgeon (i.e., long lifespan, extended residence in riverine and estuarine habitats, benthic predator) predispose the species to long-term and repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants. Chemicals and metals such as chlordane, DDE, DDT, dieldrin, PCBs, cadmium, mercury, and selenium settle to the river bottom and are later incorporated into the food web as they are consumed by benthic feeders, such as sturgeon or macroinvertebrates. Some of these compounds may affect physiological processes and impede the ability of a fish to withstand stress, while simultaneously increasing the stress of the surrounding environment by reducing DO, altering pH, and altering other water quality properties.

Stressor: Destruction/modification of habitat: Climate change (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Climate change has potential implications for the status of the Gulf sturgeon through alteration of its habitat. The Intergovernmental Panel on Climate Change (IPCC 2007) concluded that it is very likely that heat waves, heat extremes, and heavy precipitation events over land will increase during this century. Warmer water, sea level rise and higher salinity levels could lead to accelerated changes in habitats utilized by Gulf sturgeon. Both droughts and floods could become more frequent and more severe, which would affect river flow, water temperature, water quality, channel morphology, estuarine salinity regimes, and many other habitat features important to the conservation of Gulf sturgeon. A rise in water temperature may create conditions suitable for invasive and exotic species. Higher water temperatures combined with increased nutrients from storm runoff may also result in increased invasive submerged and emergent water plants and phytoplankton which are the foundation of the food chain (FWC 2009). New species of freshwater fishes may become established with warmer water temperatures (FWC 2009). The rate that climate change and corollary impacts are occurring may outpace the ability of the Gulf sturgeon to adapt given its limited geographic distribution and low

dispersal rate. (USFWS, 2009).

Stressor: Fisheries bycatch; inadequacy of existing regulatory mechanisms (USFWS 2009)
Exposure:
Response:
Consequence:
Narrative: Although confirmed reports are rare, it is still a common opinion among Gulf sturgeon researchers that possibly significant Gulf sturgeon mortality occurs as bycatch in fisheries directed at other species. Although a number of steps have been taken to reduce the potential for Gulf sturgeon to be incidentally caught by anglers or commercial operations, existing regulatory mechanisms are inadequate to prevent take of adult Gulf sturgeon due to fishing bycatch. Because the loss of a few reproducing adults directly affects population size and growth, inadequately regulated bycatch continues to be a threat (USFWS, 2009).

Stressor: Toxic algal blooms (red tides)(USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Red tide is the common name for a harmful algal bloom (HAB) of marine algae (Karenia brevis) that can make the ocean appear red or brown. K. brevis is one of the first species ever reported to have caused a HAB and is principally distributed throughout the Gulf of America, with occasional red tides in the mid- and south-Atlantic United States. K. brevis naturally produces a brevetoxin that is absorbed directly across the gill membranes of fish or through ingestion of algal cells. While many HAB species are nontoxic to humans or small mammals, they can have significant effects on aquatic organisms. Fish mortalities associated with K. brevis events are very common and widespread. The mortalities affect hundreds of species during various stages of development. Intoxication begins with binding of PbTx to specific receptor sites in fish excitable tissues (Baden and Mende 1982). Signs of intoxication in fish include violent twisting and corkscrew swimming, defecation and regurgitation, pectoral fin paralysis, caudal fin curvature, loss of equilibrium, quiescence, vasodilation, and convulsions, culminating in death due to respiratory failure. Mortality typically occurs at concentrations of 2.5 x 105 K. brevis cells/L, which is often considered to be a lethal concentration. However, it is known that fish can die at lower cell concentrations and can also apparently survive in much higher concentrations (at 3 million cells/L). In some instances, mortality from red tide is not acute but may occur over a period of days or weeks of exposure to subacute toxin concentrations. Since the 1990's the blooms of red tide have been increasing in frequency; the most recent outbreak occurred in 2007 and 2008. Red tide was the probable cause of death for at least 20 Gulf sturgeon in Choctawhatchee Bay in 1999 (USFWS 2000). Dead and dying Gulf sturgeon were reported to the FWRI Fish Kill Hotline in January 2006 attributed to post-bloom exposure (http://research.myfwc.com/features). More frequent or prolonged algal blooms may result from longer growing seasons predicted with climate change (FWC 2009). Red tides will likely continue to increase in frequency. Based on the best available information, toxins associated have likely killed Gulf sturgeon at both the juvenile and adult life stages. Because the loss of a small number of reproducing adults can have a significant overall effect on the status and trend of the population red tide is a threat to the Gulf sturgeon (USFWS, 2009).

Stressor: Aquaculture (USFWS, 2009)
Exposure:

Response:
Consequence:
Narrative: Although BMPs have been issued for Florida, and the Department monitors farms with sturgeon onsite, the risk of hybridization and escapement still occurs. The best screening of water pipes to ensure fish do not escape via irrigation systems does not guarantee that full containment, especially for fish of smaller sizes. Effects of wind and rain associated with hurricanes and unusual weather events can cause overflow of tanks, impacts to irrigation systems, and result in unintended escape of fish. The geographic location of many farms nearby streams and rivers would allow easy entry of farmed fish into sturgeon habitat. As many farms use spring-fed wells as their source for irrigation, sturgeon raised in farms have likely acclimated to local water temperatures and would presumably survive in local rivers. While effects of intra-specific competition between native and non-natives sturgeons are unknown, it is likely that habitat overlapping would occur as well as a potential for introduction of disease. Other states within the geographic range of the Gulf sturgeon have not implemented similar licensing, monitoring or BMPs (USFWS, 2009).

Stressor: Direct mortality: Collisions with boats
Exposure:
Response:
Consequence:
Narrative: Collisions with boats (aka ship strikes) may be an emerging threat to Gulf sturgeon; ship strikes are a documented threat to Atlantic sturgeon (Assrt 2007). FFWC personnel pulled a live juvenile Gulf sturgeon (< 1 m TL) with a partially severed tail from the Apalachicola River immediately following the passage of a barge tow at river mile 3.5 on September 29, 2004 (E. Lovestrand, pers. comm. 2004). The individual died within an hour after being rescued. Public outreach and education is improving to alert boaters to slow down in areas where Gulf sturgeon are known to jump. However, the number of boating trips has been and is likely to continue increasing. Combined with the potential of extended droughts in the southeast that result in lowering the water level and subsequently concentrates both sturgeon and boaters into a smaller riverine cross-section, this threat is likely to increase. Boating collisions along with the potential mortality of adult Gulf sturgeon will threaten the stability of these small populations (USFWS 2009).

Recovery

Reclassification Criteria:
Not available

The 1995 Recovery Plan outlined three recovery objectives: (1) to prevent further reduction of existing wild populations of Gulf sturgeon within the range of the subspecies; (2) to establish population levels that would allow delisting of the Gulf sturgeon by management units (management units could be delisted by 2023 if required criteria are met); (3) to establish, following delisting, a self-sustaining population that could withstand directed fishing pressure within management units (USFWS 1995). Although the tasks outlined in the 1995 Recovery Plan address threats relative to listing factors (e.g., habitat modification, overutilization, water quality, etc.), the plan lacks criteria that would measure progress towards reducing these threats. The most recent Gulf sturgeon 5-year review recommended that criteria be developed in a revised recovery plan (USFWS 2009b) (NMFS Chlorpyrifos, Diazinon, and Malathion BiOp,

2017).

Delisting Criteria:
1. The timeframe for delisting is based on known life history characteristics including longevity, late maturation, and spawning periodicity (USFWS, 1995).

2. A self-sustaining population is one in which the average rate of natural recruitment is at least equal to the average mortality rate over a 12-year period (which is the approximate age at maturity for a female Gulf sturgeon) (USFWS, 1995).

3. This objective will be considered achieved for a management unit when the population is demonstrated to be self-sustaining and efforts are underway to restore lost or degraded habitat (USFWS, 1995).

Recovery Actions:
- Develop and implement standardized population sampling and monitoring techniques (USFWS, 1995).
- Develop and implement regulatory framework to eliminate introductions of nonindigenous stock or other sturgeon species (USFWS, 1995).
- Reduce or eliminate incidental mortality (USFWS, 1995).
- Restore the benefits of natural riverine habitats (USFWS, 1995).
- Utilize existing authorities to protect habitat and where inadequate, recommend new laws and regulations (USFWS, 1995).
- Recovery plan updating: There is preliminary information that may support an analysis and review of the species regarding application of the DPS policy. The 1995 Recovery Plan was completed before policies were issued by the Services on the treatment of DPSs under the Act (61 FR 4722; February 7, 1996). Currently there is a lack of information to separate the species into population segments in accordance with the DPS policy across various genetic/geographic subdivisions. Once the ongoing genetic analysis investigating potential population structure is complete, the Services will determine if data support application of the DPS policy to the Gulf sturgeon (USFWS, 2009).
- Research: Standardization of survey and monitoring protocols needs to be established in order to assess the status of Gulf sturgeon populations across the range. A better understanding of some basic life history characteristics (habitat needs, energetics, and pollution impacts) would greatly assist in predicting impacts of threats, and understanding population dynamics. Additional analyses to determine genetic structure are essential to understand population structure (USFWS, 2009).
- Recovery Priority Number: 9C

Conservation Measures and Best Management Practices:
- ONGOING and FUTURE CONSERVATION ACTIVITIES Recovery Actions As described previously, three projects are currently underway that are funded under the NRDA program that focus on various aspects of habitat identification, habitat use, and population dynamics. The projects are anticipated to inform and prioritize future on-theground restoration actions taken to protect or restore Gulf Sturgeon habitat. One of the long-standing recovery actions discussed in the Recovery Plan includes the removal of sills in the Pearl and Pascagoula River systems that intermittently impede access to upstream habitats. We anticipate that NRDA funding may be directed toward either the removal of

these sills or the provision of passage at these sites, pending the results of these ongoing NRDA projects. Research and Development Standardization of survey and monitoring protocols are being implemented through multiple initiatives to assess the status of Gulf Sturgeon populations across the range. A range-wide study of juvenile sturgeon recruitment, mortality and habitat use is in progress through the Juvenile Sturgeon Dynamics Project, as is the development and implementation of a modern tagging database and data management protocols through the Population Status and Trends Study. During the latter project, specific metrics will be calculated and evaluated for inter-basin comparison of population trends. Areas of data insufficiency will be identified, providing managers the information needed to direct limited resources toward filling those gaps. Given that the recovery status of a species has much to do with the future risk of extinction, these important studies will assess the population status, trajectory, and viability of each of the seven populations, taking into consideration stochastic threats such as hurricane-related mortality, red tide, and pointsource pollution discharges. In tandem, these studies will identify factors that limit each of the seven populations from achieving higher population growth rates, lower mortality rates, or higher abundances. Future restoration and recovery efforts will be informed by this improved understanding of population status and the relative impacts of the myriad threats to recovery. Efforts are underway to develop and implement a reliable remote sensing method based on SSS for monitoring large Gulf Sturgeon. This method can be a potential substitute for more widely used labor-intensive, mark-recapture approaches to abundance estimation, or in some cases, generate abundance indexes in areas where little to no sampling has occurred. Moreover, focal habitats have not been fully identified or mapped for each population. The ability to rank the influence of limiting factors, and identify focal habitats remains a crucial aspect of prioritizing restoration approaches and geographic locations for project implementation. Hence, development of a geodatabase is also recommended that incorporates spatial datasets identifying the distribution of the five focal habitats. Improved understanding of Gulf Sturgeon spatio-temporal distribution in the context of life history needs will provide the Services a more effective baseline for evaluation of anthropogenic activities through the ESA section 7 consultation process. Early life stage (i.e., egg to larval phase) survival has emerged as a relatively sensitive variable in the age-structured population models developed for the Gulf Sturgeon (Pine et al. 2001). Long-term research is already underway to estimate recruitment and annual survival of juvenile sturgeon to test hypotheses associated with hydrologic influences on population dynamics. An overarching objective of all Gulf Sturgeon NRDA projects is to evaluate the potential benefits of enhancing or improving access to spawning habitat in the western Gulf of America. The Juvenile Sturgeon Dynamics Project also includes plans to further investigate genetic discreteness and significance of spring and fall spawning. Age-1 (or younger) fish should accurately represent the genetic makeup of the adult fish spawning in each river and enable us to eliminate the confounding effects of adult straying among adjacent systems (Kreiser 2012). This analysis will improve our understanding of potential recolonization and recovery times, and also genetic distinctness of the seven populations. Communication with individual states responsible for issuing Gulf Sturgeon research permits was recommended in the 2009 5-year review and remains a valid recommendation. The states have permitting authority (56 FR 49658; September 30, 1991) and no annual reporting to the Services is required. Summary information regarding permits granted, along with a description of the action would greatly assist the Services in tracking research and recovery. Other ongoing or emerging areas of Gulf Sturgeon research include impacts to critical habitat from large-scale dredging, marsh restoration, and off-bottom aquaculture. Several large-scale dredging and marsh restoration projects have been proposed in Gulf Sturgeon critical habitat (e.g., Gulf Spill Restoration – Restorations Areas 2020) and the impact of depth modification over broad swaths of estuarine habit are poorly understood and difficult to predict (Van Dolah et al. 1984, Kelaher et al.

2003); however, these projects can result in long-term alterations in benthic habitat composition and associated alterations in benthic community structure that may reduce foraging opportunities for Gulf Sturgeon (Quigley and Hall 1999). Offbottom shellfish aquaculture is also increasing in estuarine and nearshore areas of the Gulf of America and the effects of these activities on Gulf Sturgeon foraging habitat and behavior are unclear. Focused research on Gulf Sturgeon movement, prey species, and water quality in these areas would greatly improve the Services' ability to evaluate these project types (USFWS, 2022).

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SPECIES ACCOUNT: *Acipenser transmontanus* (White sturgeon (Kootenai River))

Species Taxonomic and Listing Information

Listing Status: Endangered; 09/06/1994; Pacific Region (Region 1) (USFWS, 2016)

Physical Description

A very large fish (sturgeon). The largest North American freshwater fish; maximum length about 610 cm, maximum mass 1800 lbs (816 kg). NatureServe, 2015)

Taxonomy

Eight species of sturgeon occur in North America with white sturgeon being one of five species in the genus Acipenser. White sturgeon were first described by Richardson in 1863 from a single specimen collected in the Columbia River near Fort Vancouver, Washington (Scott and Crossman 1973). White sturgeon are distinguished from other Acipenser by the specific arrangement and number of scutes (bony plates) along the body (Scott and Crossman 1973). (USFWS, 1999)

Current Range

Pacific slope of North America from Aleutian Islands, Alaska, to Monterey, California (Lee et al. 1980). A land-locked population occurs in upper Columbia River system. Significant populations occur in the Sacramento, Columbia, and Fraser rivers. Introduced in lower Colorado River, Arizona (Page and Burr 1991). (NatureServe, 2015)

Distinct Population Segments Defined

Yes; U.S.A. (ID, MT), Canada (B.C.), (Kootenai R. system) (USFWS, 2016)

Critical Habitat Designated

Yes; 7/9/2008.

Legal Description

On July 9, 2008, the U.S. Fish and Wildlife Service (Service), revised the designation of critical habitat for the Kootenai River population of the white sturgeon (Acipenser transmontanus) (Kootenai sturgeon) under the Endangered Species Act of 1973, as amended (Act). In total, 18.3 river miles (RM) (29.5 river kilometers (RKM)) of the Kootenai River are designated as critical habitat within Boundary County, Idaho.

Critical Habitat Designation

Critical habitat is designated in Idaho, Boundary County, on the Kootenai River from river mile (RM) 141.4 (river kilometer (RKM) 228) to RM 159.7 (RKM 257). Included within this designation is the 0.9 mi (1.5 km) transition zone that joins the meander and braided reaches at Bonners Ferry.

The reach of the Kootenai River designated as critical habitat lies within ordinary high-water marks as defined for regulatory purposes (33 CFR 329.11). Upon achieving Statehood in 1890, the State of Idaho claimed ownership of the bed of the Kootenai River and its banks up to ordinary high-water marks. Based upon early U.S. Forest Service (USFS) maps from 1916, U.S. Geological

Survey maps from 1928, and the confining effects of the private levees completed by the Corps in 1961, it appears that the ordinary high-water marks originally delineating State lands on the Kootenai River in the upper meander reach and braided reach are essentially unchanged. Because of the scale of the available maps, it is possible that minor river channel changes have occurred since Statehood, and that some small portions of private lands now occur within the ordinary high-water marks. However, the Service understands that most of the lands where these changes may have occurred lie within the flowage and seepage easements purchased by the Federal government under Public Law 93–251, section 56, passed in 1974 (Ziminske 1999). In addition, when the river meanders, the ‘‘government lot’’ or parcel owners abutting State-owned riverbeds and banks may request parcel boundary adjustments to the new ordinary high-water mark, and corresponding adjustments in taxable acreage. The lateral extent of the Stateowned riverbeds and banks along the steep levees may be closely approximated today through the Corps’ definition of ordinary high-water mark cited above. Thus, the Service believes the areas designated as critical habitat are within lands owned by the State of Idaho. Braided Reach: The braided reach begins at RM 159.7 (RKM 257), below the confluence with the Moyie River, and extends downstream within the Kootenai River to RM 152.6 (RKM 246) below Bonners Ferry. Within this reach the valley broadens, and the river forms the braided reach as it courses through multiple shallow channels over gravel and cobbles (Barton et al. 2004). This reach was occupied by Kootenai sturgeon at the time of listing, and is currently occupied by foraging and migrating sturgeon. Tagged female sturgeon moved into the braided reach above Bonners Ferry during the spawning period in 2006, although it is not known whether spawning occurred in the area (Kootenai Sturgeon Recovery Team 2006, pp. 1–2). Gravel and cobble are exposed along the bottom of the Kootenai River in the braided reach (Barton et al. 2004, pp. 18–19; Berenbrock 2005a, p. 7), and water velocities in excess of 3.3 ft/s (1 m/s) are likely achieved on a seasonal basis due to the high surface gradient in this reach (Berenbrock 2005a, Figure 11, p. 23). At present, the braided reach provides the temperatures, depths, and velocities required to trigger spawning only occasionally, and these features require special management for spawning sturgeon. Meander Reach: The meander reach begins at RM 152.6 (RKM 246) below Bonners Ferry, and extends downstream to RM 141.4 (RKM 228) below Shorty’s Island. This reach was occupied by Kootenai sturgeon at the time of listing, is used by foraging and migrating sturgeon, and is currently the primary spawning reach for Kootenai sturgeon (Paragamian et al. 2002, p. 608, and references therein). Although most of the reach is composed primarily of sand substrates unsuitable for successful spawning, some limited areas of gravel and cobble are present or at least exposed intermittently (Paragamian et al. 2002, p. 609; Barton et al. 2004, pp. 18–19). Although appropriate depths are available on occasion in this reach (Paragamian et al. 2001, Table 2, p. 26; Barton 2004, Table 1, p. 9; Berenbrock 2005a, p. 7), the temperatures and velocities required for successful spawning require special management to be achieved on more than an infrequent basis.

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements of critical habitat for the Kootenai River population of the white sturgeon are:

(i) A flow regime, during the spawning season of May through June, that approximates natural variable conditions and is capable of producing depths of 23 feet (ft) (7 meters (m)) or greater when natural conditions (for example, weather patterns, water year) allow. The depths must occur at multiple sites throughout, but not uniformly within, the Kootenai River designated critical habitat.

(ii) A flow regime, during the spawning season of May through June, that approximates natural variable conditions and is capable of producing mean water column velocities of 3.3 feet per second (ft/s) (1.0 meters per second (m/s)) or greater when natural conditions (for example, weather patterns, water year) allow. The velocities must occur at multiple sites throughout, but not uniformly within, the Kootenai River designated critical habitat.

(iii) During the spawning season of May through June, water temperatures between 47.3 and 53.6 degrees Fahrenheit (°F) (8.5 and 12 degrees Celsius (°C)), with no more than a 3.6°F (2.1°C) fluctuation in temperature within a 24-hour period, as measured at Bonners Ferry.

(iv) Submerged rocky substrates in approximately 5 continuous river miles (8 river kilometers) to provide for natural free embryo redistribution behavior and downstream movement.

(v) A flow regime that limits sediment deposition and maintains appropriate rocky substrate and inter-gravel spaces for sturgeon egg adhesion, incubation, escape cover, and free embryo development.

Special Management Considerations or Protections

The threats to the physical and biological features in the area designated as critical habitat that may require special management considerations or protections include shallow water depths (loss of deeper water habitat), low water velocities, and sudden drops in water temperature that adversely affect Kootenai sturgeon breeding behavior.

Life History

Feeding Narrative

<u>Adult:</u> White sturgeon in the Kootenai River system and elsewhere are considered opportunistic feeders. Partridge (1983) found white sturgeon more than 70 centimeters (28 inches) in length feeding on a variety of prey items including clams, snails, aquatic insects, and fish. Young feed mostly on the larvae of aquatic insects, crustaceans, and molluscs. A significant portion of the diet of larger sturgeon consists of fish. A bottom feeder. (USFWS, 1999; NatureServe, 2015)

Reproduction Narrative

<u>Adult:</u> White sturgeon are broadcast spawners, releasing their eggs and sperm in fast water. Based upon recent studies, Kootenai River white sturgeon spawn during the period of historical peak flows from May through July (Apperson and Anders 1991; Marcuson 1994). Spawning at peak flows with high water velocities disperses and prevents clumping of the adhesive eggs. Following fertilization, eggs adhere to the river substrate and hatch after a relatively brief incubation period of 8 to 15 days, depending on water temperature (Brannon et al. 1984). Recently hatched yolk-sac larvae swim or drift in the current for a period of several hours and then settle back into interstitial spaces in the substrate. Larval white sturgeon require an additional 20 to 30 days to metamorphose into juveniles with a full complement of fin rays and scutes. In the Columbia River, white sturgeon spawn May-July (Wydoski and Whitney 1979). In California, spawning apparently occurs between mid-March and early June (Moyle 1976). Spawning occurs at intervals of 4 to 11 years. Males may reach sexual maturity in about 9 years, females in 13-16 years (Wydoski and Whitney 1979). May live over 100 years. (USFWS, 1999; NatureServe, 2015)

Geographic or Habitat Restraints or Barriers

Adult: Dam lacking a suitable fishway; high waterfall; upland habitat that is very unlikely to be submerged even during periods of exceptionally high water (e.g., 100-year flood or 1% flood). (NatureServe, 2015)

Environmental Specificity

Adult: Low (NatureServe, 2015)

Site Fidelity

Adult: Low (NatureServe, 2015)

Habitat Narrative

Adult: Found at sea, usually near shore, and in large cool rivers or streams. Spawns probably either over deep gravel riffles or in deep holes with swift currents and rock bottoms (Wydoski and Whitney 1979). In the Fraser River (river km 98-181), British Columbia, six spawning sites were identified; five were in side channels within the meandering reach (km 98-143); one spawning site was in the main channel in the confined reach (km 145-181) (Perrin et al. 2003). Migrates upstream to spawn, moves back downstream when spawning is completed. (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: High (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Migratory, anadromous (NatureServe, 2015)

Dispersal

Adult: High (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Some are anadromous and make extensive saltwater migrations. Many move more locally from estuaries to fresh water, or farther inland within fresh water, to spawn. (NatureServe, 2015)

Population Information and Trends

Population Trends:

Variable depending on location (NatureServe, 2015)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

10,000 to >1,000,000 individuals (NatureServe, 2015)

Population Narrative:

Long-lived, slow growing, slow to reach maturity and spawns at intervals of 2-11 years (Columbia River basin). Abundant within portions of the range. Lee et al. (1980) mapped approximately 24 collection sites in 17 waterways. In the Columbia River basin, population status and recruitment success vary widely; in general, currently relatively stable at a high population size in the lower Columbia river, stable or variable at low to moderate population sizes in middle reaches, and stable at extremely low to negligible population sizes in the upper basin (Miller et al. 2002). Five of the nine populations located between dams on the Middle Snake River have declined from historical levels and are now at risk of extinction (Jager et al. 2002). The Kootenai River population has been declining since the mid-1960s; significant natural recruitment occurred most recently in 1974; by the mid-1990s, poor recruitment led to a population in which 90 percent of the individuals were more than 20 years old (see Anders et al. 2002). (NatureServe, 2015)

Threats and Stressors

Stressor: Dams (USFWS, 1999)
Exposure:
Response:
Consequence:
Narrative: White sturgeons have been detrimentally impacted by physical and ecological barriers and population fragmentation caused by dams and their impoundments. For example, dams on the Columbia River have restricted movements of white sturgeons, and impounded fishes are effectively prevented from accessing the river's estuary and the Pacific Ocean (Rien and North 2002). Dam operations during low flow produce erratic conditions for spawning and recruitment (Parsley and Beckman 1994, Beamesderfer et al. 1995). Dams on the Snake River have reduced free-flowing habitat by 37 percent (Cochnauer 2002). Most hydroelectric dams on the Snake River were never fitted with fish ladders adequate to allow upstream passage of white sturgeons (Cochnauer 2002). (NatureServe, 2015)

Stressor: Fishing (USFWS, 1999)
Exposure:
Response:
Consequence:
Narrative: Populations were severely reduced by commercial over-fishing in the late 1800s-early 1900s (Parsley et al. 2002). As of the early 1990s, populations in Canada were "healthy" but under increasing pressure from fisheries (Lane 1991). (USFWS, 1999)

Stressor: River flow changes (USFWS, 1999)
Exposure:
Response:
Consequence:
Narrative: The significant change to the natural flows in the Kootenai River caused by flow regulation at Libby Dam is considered to be a primary reason for the Kootenai River white sturgeon’s continuing lack of recruitment and declining numbers. Beginning with the partial operation of Libby Dam in 1972 (though not fully operational until 1974), average spring peak flows in the Kootenai River have been reduced by more than 50 percent, and winter flows have increased by 300 percent compared to pre-dam values (Figure 3). As a result of original Libby

Dam operations until the initiation of experimental flows in 1992, the natural high spring flows thought to be required by white sturgeon for reproduction rarely occurred during the May to July spawning season when suitable temperature, water velocity, and photoperiod conditions would normally exist. In addition, cessation of periodic flushing flows has allowed fine sediments to build up in the Kootenai River bottom substrates. This sediment fills the spaces between river bed cobbles, reducing fish egg survival, larval and juvenile fish security cover, and insect production. (USFWS, 1999)

Stressor: Diking and bank stabilization (USFWS, 1999)
Exposure:
Response:
Consequence:
Narrative: Additionally, the elimination of side-channel slough habitats in the Kootenai River flood plain due to diking and bank stabilization to provide flood protection for agricultural land; development of Creston Valley Wildlife Management Area in British Columbia and Kootenai National Wildlife Refuge in Idaho; and lower Kootenay Lake spring maximum elevations are also a contributing factor to the white sturgeon decline. Much of the Kootenai River has been channelized and stabilized from Bonners Ferry downstream to Kootenay Lake resulting in reduced aquatic habitat diversity, altered flow conditions at potential spawning and nursery areas, and altered substrates in incubation and rearing habitats necessary for survival (Partridge 1983, Apperson and Anders, 1991). (USFWS, 1999)

Stressor: Water temperatures (USFWS, 1999)
Exposure:
Response:
Consequence:
Narrative: As a consequence of altered flow patterns, average water temperatures in the Kootenai River are typically warmer (by 3 degrees Celsius; 37 degrees Fahrenheit) during the winter and colder (by 1 - 2 degrees Celsius; 34 - 36 degrees Fahrenheit) during the summer than prior to impoundment at Libby Dam (Partridge 1983). However, during large water releases and spills at Libby Dam in the spring, water temperatures in the Kootenai River may be colder than under normal non-spill spring flow conditions. (USFWS, 1999)

Stressor: Water quality (USFWS, 1999)
Exposure:
Response:
Consequence:
Narrative: The overall biological productivity of the Kootenai River downstream of Libby Dam has been altered. Based on limnological studies of Kootenay Lake, Daley et al. (1981) concluded that the construction and operation of Libby Dam (and Duncan Dam, British Columbia) "...has drastically altered the annual hydrograph and has resulted in modifications to the quality of water now entering the lake by removing nutrients, by permitting the stripping of nutrients from the water in the river downstream from Libby Dam, and altering the time at which the nutrients are supplied to the lake." Potential threats to Kootenai River white sturgeon from declining biological productivity include decreased prey abundance and food availability for some life stages of sturgeon downstream of Libby Dam, and possible reduction in the overall capacity for the Kootenai River and Kootenay Lake to sustain substantial populations of white sturgeon and other native fishes. For example, total zooplankton densities in the Kootenai River at Bonners

Ferry (mean fewer than 0.1 organism/liter) are lower than in other rivers of the northwestern United States (Paragamian 1994). (USFWS, 1999)

Stressor: Contaminants (USFWS, 1999)
Exposure:
Response:
Consequence:
Narrative: Apperson (1992) noted detectable levels of aluminum, copper, lead, zinc, and strontium, along with polychlorinated biphenyls (PCB) and pesticides, in white sturgeon egg samples from the Kootenai River. However, other than copper, detectable levels of these compounds, e.g. polychlorinated biphenyls, organochlorides, and zinc, were lower than levels found in other Columbia River basin white sturgeon that successfully reproduce. Ultimately, the overall effects of these pollutants on sturgeon reproduction and survival are unknown. Kootenai River white sturgeon eggs have been hatched under experimental hatchery conditions using both Kootenai River water and domestic city water, however the chronic effects of heavy metals on egg hatching success and the dietary pathways of larvae and young-of-the-year white sturgeon have not been investigated. Georgi (1993) noted that the chronic effects on wild sturgeon spawning in "chemically polluted" water and rearing over contaminated sediments, in combination with bioaccumulation of contaminants in the food chain, is possibly reducing the successful reproduction and early-age recruitment to the Kootenai River white sturgeon population. (USFWS, 1999)

Recovery

Reclassification Criteria:
1. Natural production of white sturgeon occurs in at least 3 different years of a 10-year period; a naturally produced year class is demonstrated when at least 20 juveniles from a year class are sampled at more than 1 year of age. (USFWS, 1999)

2. The estimated white sturgeon population is stable or increasing and juveniles reared through a conservation aquaculture program are available to be added to the wild population each year fora 10-year period. Each of these year classes must be large enough to produce 24 to 120 sturgeon surviving to sexual maturity. (USFWS, 1999)

3. A long-term Kootenai River Flow Strategy is developed in coordination with interested State, Federal, and Canadian agencies and the Kootenai Tribe at the end of the 10-year period based on results of ongoing conservation efforts, sturgeon habitat research, and fish productivity studies. An important element of this strategy is demonstration of the repeatability of in-stream environmental conditions necessary to produce recruits (as described above) in future years. (USFWS, 1999)

Downlisting Criterion – Kootenai sturgeon demonstrate consistent natural in-river production of juveniles, with production of wild age-3 juveniles occurring at an annual average of at least 700 individuals over 10 consecutive years. Production of 700 or more wild age-3 juveniles occurs in at least 3 of the 10 years, ensuring the annual average is not the result of an anomalous single-year event (USFWS, 2019).

Delisting Criteria:

Delisting Criterion – The number of Kootenai sturgeon wild recruits (offspring that survive to sexual maturity at 25 years of age) added to the adult (25 years or older) population annually averages at least 250 individuals per year over 10 years. In addition, the population includes at least 10,000 wild juveniles aged from 3 to 24 years (USFWS, 2019).

Recovery Actions:

- Identify and restore white sturgeon habitats necessary to sustain white sturgeon reproduction (spawning and early age recruitment) and rearing while minimizing impacts on other uses of Kootenai River basin waters. (USFWS, 1999)
- Develop and implement a conservation aquaculture program to prevent the extinction of Kootenai River white sturgeon. The conservation aquaculture program will include protocols on broodstock collection, propagation, juvenile rearing, fish health, genetics, and stocking. (USFWS, 1999)
- Work within operational guidelines for Libby Dam based upon Kootenai Integrated Rule Curves (KIRC) developed by Montana Fish, Wildlife, and Parks to balance white sturgeon recovery with requirements for other aquatic species and recreational fisheries within the Kootenai River drainage, and VARQ (an enhanced flood control protocol), to ensure that more water is available for white sturgeon, salmon, and all species in lower water years. (USFWS, 1999)
- Continue research and monitoring programs (with achievable and measurable objectives) on life history, habitat requirements for all life stages, population status, and trends of the Kootenai River white sturgeon. (USFWS, 1999)
- Protect Kootenai River white sturgeon and their habitats using available regulatory mechanisms. (USFWS, 1999)
- Evaluate how changes in biological productivity in the Kootenai River basin affect white sturgeon and their habitats. (USFWS, 1999)
- Evaluate the effects of contaminants and possible additional biological threats, e.g. predation and species composition, on Kootenai River white sturgeon and their habitats. (USFWS, 1999)
- Increase public awareness of the need to protect and recover Kootenai River white sturgeon. (USFWS, 1999)
- Balance white sturgeon recovery measures with requirements for other aquatic species and recreational fisheries within the Kootenai River drainage. (USFWS, 1999)
- Secure funding for implementation of recovery tasks. (USFWS, 1999)
- Continue efforts to establish a self-sustaining, naturally-reproducing population of Kootenai sturgeon through the release of hatchery origin sturgeon. (USFWS, 2011)
- Continue research and monitoring of Kootenai sturgeon. (USFWS, 2011)
- Continue to manage flows from Libby Dam to benefit Kootenai sturgeon. (USFWS, 2011)
- Continue to support the Kootenai Tribe of Idaho ecosystem restoration project. (USFWS, 2011)
- Revise existing recovery plan. (USFWS, 2011)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Continue to implement the conservation aquaculture program. 2. Continue to manage flow and temperature from Libby Dam ensure spawning and rearing conditions are appropriate. 3. Continue to add nutrients to the Kootenai ecosystem. 4. Continue to implement habitat restoration and enhancement projects in the Kootenai basin. 5. Support Kootenai River white sturgeon recovery efforts with research and monitoring that will inform adaptive management, and conduct a public outreach program (USFWS, 2018). 1.0 Conservation Aquaculture 1.1 Continue conservation aquaculture program As discussed in the Recovery Vision and Strategy section above, current natural recruitment levels cannot sustain pre-dam population estimates of 8,000 adults, further suggesting that high levels of mortality are occurring during early life stages. As such, recruitment failure continues to be a major threat to population persistence and recovery (Anders et al. 2014, 2016). In order to address recovery and fill the demographic and genetic gaps left by limited natural reproduction, hatchery-origin Kootenai Sturgeon have been spawned from wild broodstock and released into the Kootenai River (throughout the range of Kootenai sturgeon) annually beginning in 1992. Since 1992, the Kootenai Tribe's Kootenai Sturgeon aquaculture program has released over 284,000 hatchery-origin juvenile Kootenai sturgeon into the Kootenai River basin. From 1995 to2014, 2,000– 40,000 juveniles ranging from age-0 to age-4 (mainly age-1) were released annually. Year classes were genetically represented by as many as 18 families ("family" = 1 female crossed with 1 male) until 2015 when the addition of the Twin Rivers Hatchery allowed for an increase in representation to 30 families per year class. 22 Releases from 1992 to 1994 were largely experimental and constituted small year classes of variable ages and size. From 1999 to 2003, the addition of a second hatchery facility allowed annual releases to increase approximately 10,000 age-1 and age-2 juveniles. From 2004 to 2006, sturgeon managers focused on releasing a high number of smaller, age-0 and age-1 juveniles in order to maximize genetic diversity. Average annual releases increased to approximately 34,000 juveniles with a mean weight of only 0.35 ounces. Then beginning in 2007, the focus returned to a strategy similar to that of 1999 to 2003 (average annual releases of approximately 12,500 age-1 juveniles). There have been multiple estimates of post-release survival rates of hatchery-origin Kootenai sturgeon. Ireland et al. (2002) estimated that hatchery juvenile Kootenai sturgeon survived at high rates after release, with 60 percent survival the first year after release and 90 percent the following years. Later analyses showed that hatchery origin Kootenai sturgeon released at smaller sizes survived at significantly lower rates than those released at larger sizes (Justice et al. 2009; Beamesderfer et al. 2014a; Dinsmore et al. 2015). In response, sturgeon managers recommended that hatchery origin Kootenai sturgeon released at age-1 be released when they are greater than approximately 10 inches fork length. Dinsmore et al. (2015) concluded that estimates of age-1 post-release survival have "declined dramatically since the early 1990s" (from 88 percent to less than 13 percent), but annual post-release survival at age-2 and older has been higher (64 to 95 percent for previously released age-2 fish, and over 92 percent for age-3+) and shows no evidence of decline. Additionally, Dinsmore et al. (2015) found that survival rates of fish released during the spring were 40 percent greater than those released in summer. Recent genetic survey data indicate that differential post-release survival between family groups has affected the representation of wild alleles in the hatchery-origin population (Schreier et al. 2015). As discussed above, aquaculture strategies have varied over the history of the program, resulting in differential post-release survival among families. Nevertheless, the data indicate that in brood years 2002 to 2009, approximately 70 to 80 percent of wild alleles were represented in surviving hatchery-origin juveniles (A. Schreier, pers. comm. 2016). These results, in addition to the continued low level of natural in-river recruitment among Kootenai sturgeon, make it clear that continuing the conservation aquaculture program with an adaptive management approach, as noted below, is vital to the recovery of the species. 1.2 Continue to adaptively manage conservation aquaculture program Continue to utilize monitoring data (from Action 5.1 below) to guide and refine implementation of the conservation aquaculture program in an adaptive management framework. The current program uses a rearing strategy based upon 25 years of monitoring, research, and evaluation and will continue to adapt as necessary depending on future results. 23 The Kootenai Tribe's Sturgeon Conservation Program

Annual Program Review provides an ongoing venue to determine the use and the specific biological targets of the conservation aquaculture program. Decisions are based upon the most up to date science, hatchery functions/capabilities, and input from co-managing agencies. 2.0 Flow and Temperature Management: Continue to manage flow and temperature from Libby Dam to benefit Kootenai sturgeon It is important to note that it is not possible to achieve historical flow and temperature regimes in the Kootenai River due to flood risk management operations at Libby Dam. To manage flood risk downstream from Libby Dam, the USACE manages the dam's outflow so that river stage does not exceed 1,764 feet (mean sea level) at Bonners Ferry, Idaho. Elevation constraints for Kootenay Lake also prevent water managers from allowing flows in the Kootenai River below Libby Dam to approach historical spring flood levels. Thus, it is important to note that it is not possible to fully evaluate the hypothesis that regulated (reduced) peak spring flows and stages at Bonners Ferry are responsible for Kootenai sturgeon reproductive failure. Sturgeon managers will continue to coordinate annually via the Kootenai River Ecosystem Function Restoration Flow Plan Implementation Protocol (FPIP). The FPIP includes a technical team that develops an annual recommendation on the shape, timing, and duration of expenditure of the tiered sturgeon volume, generally during late May into early June. The FPIP technical team is composed of regional biologists and water managers, and is independent of the Kootenai River White Sturgeon Recovery Team, though representation is very similar. Annual planning for Kootenai sturgeon flow augmentation operations commences with preparation of a draft sturgeon flow recommendation and associated monitoring plan by the action agencies (USACE and BPA) and the Service during early spring. The draft flow recommendation and monitoring plans are reviewed by the entire FPIP technical team, and then submitted to the FPIP policy team for review. Upon policy team approval, the plans are submitted to the Service, which prepares a Systems Operation Request (SOR) for Kootenai sturgeon flow augmentation based on the FPIP flow recommendation, and submits it to the USACE via the Technical Management Team (TMT) of the Columbia River Regional Forum. The SOR is discussed and approved by the TMT prior to commencement of flow augmentation. The FPIP technical team holds coordination calls regularly prior to, and throughout, the augmentation period. Managers may also need to consider the effects of climate change on sturgeon operations. As climate change alters hydrologic regimes, reservoir operations (e.g., refill schedules, flood risk management rule curves, and flood operating criteria) may need to be adjusted in order to maintain reliable water deliveries, power generation, support for environmental needs, and flood risk management (USACE et al. 2017). Multiple climate model simulations project that annual average surface temperatures will increase approximately 2.2° F by the 2020s and 3.5° F by the mid-21st century, compared to the average for 1970 to 1999 (Mote and Salathé 2010), with the greatest increases occurring 24 in the summer. Predictions regarding precipitation are less certain, but the general expectation is for decreased summer precipitation and increased winter precipitation. Specific to the Northern Rocky Mountains area, predictions are for warmer springs, earlier snowmelt, and hotter, drier summers with longer fire seasons (USACE et al. 2017). Together, these scenarios would alter inflow patterns and reservoir/river water temperatures in the region. Reservoir systems in the Columbia River basin were designed under the assumption that snowpack would act as an additional reservoir, holding water (in the form of snow) during the cool season and gradually releasing it in the summer months (USACE et al. 2017). Similarly, ecosystems in the Columbia River basin have evolved to exist within specific hydrologic regimes. Climate change impacts to water supplies, runoff patterns, and water demands are likely to stress these systems, which will in turn affect management of the system (USBOR 2016). However, there is uncertainty regarding predictions relative to the precise extent and timing of changes that may occur in the Kootenai River basin and the subsequent adjustments and actions that will need to be taken. 3.0 Nutrient Addition: Continue, and possibly expand, nutrient addition projects Due to the loss of historical floodplains and the trapping of nutrients behind Libby

Dam, an experimental river fertilization project implemented by the Kootenai Tribe and IDFG began in the Kootenai River just downstream from the Idaho-Montana border in 2005. Additionally, the BCMFLNRORD, BC Hydro, BPA, and Kootenai Tribe have ongoing programs to fertilize the north and south arms of Kootenay Lake to increase biological productivity and restore native fish populations and nutrient routing through their supporting food webs. Continuing these nutrient programs will continue to increase overall biological productivity in the Kootenai system (Hoyle et al. 2014; Minshall et al. 2014), and ideally thereby alleviate the threats to Kootenai sturgeon associated with loss of nutrients and primary productivity. 4.0 Restore and Enhance Habitat 4.1 Increase in-river habitat complexity Restore and enhance in-river habitat complexity in reaches of the Kootenai River occupied by Kootenai sturgeon by constructing, creating, or enhancing additional or existing pools, riffles, eddies, islands, side channels, and other in-river features that add to the overall habitat complexity of the river. These actions will provide the necessary diverse habitats that are needed to support all life stages (i.e., migration, occupancy, spawning, incubation, recruitment, and early rearing) of Kootenai sturgeon. 4.2 Enhance spawning habitat 25 Provide adequate rock substrates and increased hydraulic complexity (e.g., velocity, turbulence) in appropriate areas of the straight, braided, and meander reaches of the Kootenai River. Adding these features will facilitate egg attachment and improve the success of embryo incubation, as well as free-embryo and larval rearing. 4.3 Increase pool habitat Provide additional pool habitat in suitable areas of the river occupied by Kootenai sturgeon via construction of pool-forming structures, pool excavation, construction of islands, and other methods. Increasing pool habitat in these areas supports staging for spawning, holding, and resting, and will facilitate spawning migration to the braided and canyon reaches where rocky substrates, which appear conducive to successful spawning and recruitment, are present. 4.4 Restore and enhance riparian function Restore riparian vegetation on river banks and islands, both along the Kootenai River in Montana and Idaho, and along tributaries to the Kootenai River. Riparian vegetation provides important components of aquatic habitat such as overhanging bank cover and large woody debris within the river and floodplain, and provides food web support, among other important functions. Riparian vegetation includes cottonwood and conifer forests, shrub complexes and other wetland and upland habitats. Restoration strategies include management actions such as weed control and development of riparian buffers, in addition to active restoration actions such as bioengineering, direct planting, and construction of surface features. 4.5 Restore and enhance floodplain, side channel, and tributary connectivity and interaction Restore and enhance floodplain surfaces that are hydrologically connected to the main channel, to store sediment and facilitate riparian plant establishment in the Kootenai River. Re-establishment of historical off-channel (floodplain) habitats and side-channel habitat will also provide additional nutrient production and cycling, food production, and nursery habitat areas for various native fish species in the Kootenai River. Construction and reconnection of floodplain surfaces and reconnection of side channels will create diverse habitats adjacent to the river that can be accessed by average peak flows. Longterm, floodplain revegetation will increase roughness, adding a sediment filtering function that will promote sediment storage as part of natural floodplain building processes, as well as increase biological productivity in the Kootenai River system. Restoration or enhancement of tributary connectivity to the mainstem Kootenai River will also provide additional habitat complexity including potential spawning habitat in alluvial fans of tributaries, and contribute to the food web. 5.0 Research, Monitoring, and Evaluation: Continue research and monitoring of Kootenai sturgeon. 26 Although each of these identified actions inherently has research, monitoring, and evaluation needs to determine effectiveness, additional research, monitoring, and evaluation of the Kootenai River basin and Kootenai sturgeon has revealed new information vital to recovery efforts. More remains to be discovered about causes of recruitment failure and early life stage behaviors and requirements of Kootenai sturgeon. It is likely that the information gathered will also be vital to future recovery efforts. Further, continued monitoring for wild juvenile Kootenai sturgeon is important as recovery actions continue to be implemented. Should an action prove “successful” and result in a detectable increase in recruitment, it will be crucial to be able to identify the success as quickly as possible in order to link it to a specific recovery action. Research and monitoring will determine if the recovery criteria are being met. Additionally, due to the reduced abundance of wild adult Kootenai sturgeon, it is imperative that research, monitoring, and evaluation activities minimize harm to the population through sampling, handling, collecting biological samples, and other research, monitoring, and evaluation activities. This is currently addressed via the Service’s ESA section 10 permitting, which ensures that researchers and field crews have proper training and follow established protocols. 6.0 Public Outreach and Education: Continue, and expand where possible, current public outreach efforts Continuing to expand public and political support for Kootenai sturgeon recovery efforts will be vital to implementing the actions listed in this recovery plan. Without such support, acquiring funding and authorization for implementation of actions will be difficult. Therefore, it is vital to continue to inform the public, elected officials, and others about the status of Kootenai sturgeon and what needs to be accomplished in order to recover the population. Another key aspect of this process is the publishing of research results in peer-reviewed journals, which has helped to disseminate important science-based information to date (USFWS, 2019).

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SPECIES ACCOUNT: *Amblyopsis (=Troglichthys) rosae* (Ozark cavefish (=Troglichthys))

Species Taxonomic and Listing Information

Listing Status: Threatened; 11/1/1984; Southeast Region (Region 4) (USFWS, 2016)

Physical Description

The Ozark cavefish attains a maximum total length of about 50 mm. The head is dorsoventrally flattened with a slightly protruding lower jaw. The fish have no pelvic fins and the dorsal and anal fins are located more posterior than usual. The caudal fin is rounded and has two to three rows of sensory papillae on the upper and lower halves. The fish lack melanophores and appear pinkish-white (USFWS, 1989).

Taxonomy

Unpublished mtDNA data of Bergstrom, Noltie, and Holtsford indicate that the Ozark cavefish comprises four genetically distinct clades in the following drainages: White River, Missouri; Neosho River, Missouri; Neosho River, Oklahoma; and Illinois River, Arkansas; these clades may warrant recognition as subspecies; furthermore, inclusion of both rosae and A. spelaea in the genus Amblyopsis "is erroneous because they are not sister species" (see Figg and Bessken 1995). Accordingly, Page and Burr (2011) placed Ozark cavefish in the genus Troglichthys. (NatureServe, 2015)

Historical Range

Historically, the Ozark cavefish occurred in 24 caves in nine counties with unconfirmed reports in 52 caves in 14 counties (USFWS, 1989).

Current Range

Range includes the Springfield Plateau of the Ozark Highlands in southwestern Missouri, northwestern Arkansas, and northeastern Oklahoma (Brown and Willis 1984); this region is drained by the White, Neosho, and Osage rivers (USFWS 2011). There are an estimated 41 active Ozark Cavefish caves and wells in Arkansas, Missouri, and Oklahoma. The 41 active sites are distributed throughout 10 counties including Benton County in Arkansas; Greene, Jasper, Lawrence, Newton, Christian, Barry, and Stone Counties in Missouri; and Delaware and Ottawa Counties in Oklahoma. (USFWS, 2019)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Primary diet is small crustaceans; also eats small salamanders and conspecific young (Robison and Buchanan 1988). Adults and immatures are invertivores. Bat guano is the primary energy/nutrient source in the cave ecosystems where this species occurs. The highest concentration of food in caves is on the bat guano piles (NatureServe, 2015). Plankton is the primary food of A. rosae (Poulson 1963). here is also some evidence they feed directly on bat guano (USFWS, 1989). Ozark cavefish are carnivorous. Ozark cavefish consume crayfish species including cave crayfish and spot handed crayfish; eggs from darksided salamander and cave salamanders; stygobitic arthropod species such as Stygobromus onondagaensis and Stygobromus ozarkensis; as well as a species of styobitic isopod. Additionally, they are cannibalistic. A portion of the diet, during periods of hatching, may consist of newly hatched young and/or developing juvenile cavefish(Graening and Brown, 2003) (USFWS, 2016).

Reproduction Narrative

Adult: Ozark cavefish are polygynandrous species, mating at random with multiple partners in an attempt to increase population fitness, although not all females may have ova ready for fertilization. (Noltie and Wicks, 2001; Poulson, 1963; Romero, 2001). Ozark cavefish are considered sexually mature at age 4. Regardless of their sexual maturity, about 20% of the mature female population develop ova each year. It is believed that this reproductive limitation results from limited food sources in the cave. This birth limitation also helps to control food availability; lower population sizes do not demand as much food, which is limited in the cave environment. Eggs produced during each breeding period tend to be large in size and low in number when compared to similar species. (Poulson, 1963; Romero, 1998; Romero, 2001). Ozark cavefish grow at a slow rate, approximately 0.6 millimeters every month, and have a long lifespan. Because they are only viable in the wild and conservation measures restrict the capture of this species, a measure of average lifespan in captivity is not available. However, the average lifespan of wild populations is approximately 10 years(Poulson, 1963). (USFWS, 2016).

Geographic or Habitat Restraints or Barriers

Adult: Hydrological discontinuity (NatureServe, 2015)

Environmental Specificity

Adult: Very narrow (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from USFWS, 1989)

Habitat Narrative

Adult: Habitat includes dark cave waters, primarily clear streams with chert or rubble bottom, occasionally pools over silt or sand bottom. See Willis and Brown (1985). See Lister and Noltie (no date) for detailed information on the characteristics of occupied and unoccupied habitat. Separation barriers are created by hydrological discontinuity (NatureServe, 2015). The ability of A. rosae to withstand the low dissolved oxygen may be an adaptation to ground water conditions which often tend to be anoxic and is also related to its low metabolic rate, an adaptation to the low food supply of the cave environment. In order to exploit this food source, the fish must be capable of withstanding the conditions immediately below the bat roosts. The bat guano increases nutrient concentrations and the biological oxygen demand in the water (USFWS, 1989).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015)

Population Information and Trends

Population Trends:

Decline of 10-70% (NatureServe, 2015)

Species Trends:

Stable (USFWS, 2011)

Number of Populations:

41 active caves (USFWS, 2011)

Population Size:

~235 (USFWS, 2019)

Population Narrative:

The current range-wide estimate is 235 individuals compared to 213 individuals reported in the 2011 status review. The small increase in total numbers is encouraging, but an overall increase masks count variability between sampling periods at individual sites. For instance, there were an additional 11 cavefish observations at Cave Springs in 2017 compared to 2015. During the same sampling period, the number of cavefish observed at Logan Cave dropped by 19 individuals, most likely because of equipment failure during the 2017 survey (pers. comm. with Mike Slay, TNC). While cavefish are easily observable at Cave Springs and Logan caves, accessible cavefish habitat at most other caves is small. Limited accessible habitat coupled with low detectability of individuals and inconsistent periodic surveys means that the most "recent" count total may not be the best estimate for the species. Trend analysis that incorporates longer datasets of cavefish counts may be a more useful way to characterize population fluctuations (Graening et al 2010). Since the last status review, new surveys occurred at most cavefish sites a few times. Additional surveys are necessary prior to reassessing population trends (Table 2). Of populations that are undetermined and/or unoccupied, infrequency of survey and site accessibility issues may be contributing factors. (USFWS, 2019)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Of the 41 active sites, agriculture is the primary threat. As lands are converted from forest to pasture, valuable canopy cover for ground temperature regulation and soil moisture retention is lost. Chemicals and fertilizers are applied which rapidly infiltrate during precipitation events into groundwater systems. Of the 41 active sites, urbanization/development is suggested as another primary threat in recharge zones. As development increases, areas that allow natural

infiltration and percolation are lost or significantly diminished. As impervious surfaces increase, stormwater directed to engineered or natural outlets no longer finds natural groundwater flow paths. Outfalls often lead to adjacent losing streams whereby stormwater is ultimately transported to groundwater. Stormwater runoff contains numerous contaminants including automotive fluids, brake dust, roof tar, pesticides, and herbicides. Stormwater runoff leads to acute pulses of contaminated waters underground, of which some contaminants remain in the system for years. A substantial amount of groundwater contamination occurs from inadequate or un-maintained sewage disposal systems. Increased groundwater withdrawals for home, community, and agricultural use, depletes groundwater and limits available habitat (USFWS, 2011).

Stressor: Human disturbance (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Entry is the primary threat at one site in Arkansas. Six gates/fences have been vandalized with evidence of recent human access. Two of these are receiving continued unauthorized visitation, including Logan Cave which harbors the second largest population. Use at ungated caves is occurring based on evidence such as new paint, foot prints, rafts, and writing found during biannual monitoring surveys. As interest in recreational caving continues to increase, caves supporting cavefish are likely to receive additional unauthorized entry. Human entry causes increased turbidity decreasing cavefish sensory ability, increases the potential for direct mortality due to trampling of individuals, and can interrupt feeding and breeding behaviors (USFWS, 2011).

Stressor: Urbanization/development
Exposure:
Response:
Consequence:
Narrative: Of the 41 active sites, urbanization/development is a leading threat in recharge zones in northwest Arkansas and parts of southwest Missouri. As development increases, areas that allow natural infiltration and percolation are lost or significantly diminished. As impervious surfaces increase, stormwater directed to engineered or natural outlets no longer finds natural groundwater flow paths. Outfalls often lead to adjacent losing streams whereby stormwater is ultimately transported to groundwater. Stormwater runoff contains numerous contaminants including automotive fluids, brake dust, roof tar, pesticides, and herbicides. Stormwater runoff leads to acute pulses of contaminated waters underground, of which some contaminants remain in the system for years. A substantial amount of groundwater contamination occurs from inadequate or un-maintained sewage disposal systems. Increased groundwater withdrawals for home, community, and agricultural use, depletes groundwater and limits available habitat (https://www.epa.gov/nutrientpollution/sources-andsolutions-stormwater) (USFWS, 2019).

Stressor: Agriculture (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: In Benton County, Arkansas, 47.1% of land is in pasture and 28.9% is in cropland (Census of Agriculture 2012). Valuable canopy cover for ground temperature regulation and soil

moisture retention is lost due to forest conversion to pasture. Chemicals and fertilizers applied to pastures rapidly infiltrate during precipitation events into groundwater systems. Graening and Brown (2000) found metals bioaccummulated in surface crayfish removed from Cave Springs Cave. They attribute these metal concentrations to land application of poultry litter in the recharge zone. Graening further suggests the decline in amphipods and an increase in isopods may be due to an increase in nutrient loads. Cave Springs Cave and Logan Cave occur in a Nutrient Surplus Area (NSA) in Northwest Arkansas. An NSA is an area designated by the Arkansas General Assembly as having such high concentrations of one or more nutrients that continued unrestricted application of the nutrient could negatively affect soil fertility and waters of the state. The Ozarks are a leading producer of poultry in the United States (United States Department of Agriculture 2018). In Arkansas, most poultry litter land application is on pasture or forage land near production (Miller and Tharp 1994) (USFWS, 2019)

Recovery

Reclassification Criteria:
Not applicable.

Delisting Criteria:
1) Eight caves (Cave Springs and Logan in Arkansas; Twin and Engelbrecht in Oklahoma; Ben Lassiter, Kellhofers, Sarcoxie, and Turnback Creek in Missouri) and their recharge areas are protected (USFWS, 2019).

2) The [Ozark] cavefish population in each of these caves remains stable or increasing as evidenced by observation of no less than 100 per survey visit in Cave Springs and no less than 20 per survey visit in each of the other caves over at least a 10 year period (USFWS, 2019).

Recovery Actions:
- Study local and regional hydrological patterns (USFWS, 1989).
- Provide protection and management for recovery caves (USFWS, 1989).
- Develop and implement a monitoring program (USFWS, 1989).
- As the majority of community and agricultural development activities have no federal nexus, it is imperative that the Service and its partners establish cooperative relationships with city councils, planning boards, quorum courts, county commissioners, tribes, and others involved in the economic development of communities and their growth (USFWS, 2011).
- Establish trust and relationships with private landowners as the likelihood of future discovery exists mostly on private lands (USFWS, 2011).
- The recovery plan should be revised to reflect current knowledge, refine reclassification criteria, re-define delisting criteria, and accurately address the five factors (USFWS, 2011).
- Determine life history characteristics of Ozark cavefish (USFWS, 2011).
- Determine importance of gene flow between individual populations (USFWS, 2011).
- Research use of mucous samples for genetic analysis (USFWS, 2011).
- Establish methodology for the propagation of Ozark cavefish (USFWS, 2011).
- Conduct tissue analysis of non-sensitive species, and sediments in caves for contaminants and metals (USFWS, 2011).
- Continue and expand water quality monitoring, including pharmaceuticals and other contaminants (USFWS, 2011).

- Determine occurrence and accurate status of sites where cavefish have not been found within at least the last 5 years (USFWS, 2011).
- Continue monitoring of the groundwater basin within the Springfield plateau for potentiometric surface and water quality (USFWS, 2011).
- Evaluate alternatives whereby incentives are offered to cooperating private landowners, developers, and communities (USFWS, 2011).
- Investigate and install security measures at caves. These may include pressure plates, cameras, sensors, data loggers, and cave stewards (USFWS, 2011).
- Ascertain methods for Ozark cavefish population enumeration throughout the Springfield Plateau by sampling groundwater portals (i.e.: wells, springs, etc.) for cavefish. Development of a model may prove beneficial in this effort (USFWS, 2011).
- Investigate alternatives to land application of litter within recharge zones and educate landowners on appropriate setbacks from sensitive karst features and appropriate timing of land application when applying nutrients to soil (USFWS, 2011).
- RECOMMENDATIONS FOR FUTURE ACTIONS 1. As the majority of community and agricultural development activities have no federal nexus, it is imperative that the Service and its partners continue to establish and/or foster cooperative relationships with city councils, planning boards, quorum courts, county commissioners, tribes, and others involved in the economic development of communities and their growth. 28 2. Establish trust and relationships with private landowners as the likelihood of future discovery exists mostly on private lands. 3. Revise the recovery plan to reflect current knowledge, refine reclassification criteria, re-define delisting criteria, and accurately address the five factors. 4. Determine life history characteristics of Ozark Cavefish. 5. Determine the importance of gene flow between individual populations. 6. Research use of mucous samples for genetic analysis. 7. Establish methodology for the propagation of Ozark Cavefish. 8. Conduct tissue analysis of non-sensitive species, and sediments in caves for contaminants and metals. 9. Continue and expand water quality monitoring, including pharmaceuticals and other contaminants. 10. Determine occurrence and accurate status of sites with cavefish records greater than 10 years old. 11. Continue monitoring of the groundwater basin within the Springfield plateau for potentiometric surface and water quality. 12. Evaluate alternative incentives for cooperating private landowners, developers, and communities. 13. Investigate and implement security measures at caves. These may include pressure plates, cameras, sensors, data loggers, and cave stewards. 14. Ascertain methods for Ozark Cavefish population enumeration throughout the Springfield Plateau by sampling groundwater portals (i.e.: wells, springs, etc.) for cavefish. Development of a model may prove beneficial in this effort. 15. Investigate alternatives to land application of litter within recharge zones and educate landowners on appropriate setbacks from sensitive karst features and appropriate timing of land application when applying nutrients to soil (USFWS, 2019).

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SPECIES ACCOUNT: *Catostomus discobolus yarrowi* (Zuni bluehead Sucker)

Species Taxonomic and Listing Information

Listing Status: Endangered; August 25, 2014; Southwest Region (R2)

Physical Description

The Zuni bluehead sucker has a fusiform (torpedo-shaped), slender body with a subterminal mouth (mouth posterior to the tip of the snout) (Propst 1999, p. 49). Most individuals do not exceed 20.3 centimeters (cm) (8 inches (in)) in total length, although the species has been known to exceed 25 cm (9 in) in total length (Propst and Hobbes 1996, pp. 22–34). The Zuni bluehead sucker has a bluish head, silvery-tan to dark green back, and yellowish to silvery-white sides and abdomen. Adults are mottled slate-gray to almost black dorsally (upper part of the body) and cream-white ventrally (toward the abdomen). During the spawning season, males may be differentiated by coarse tubercles (wart-like projections) on the rear fins and the caudal peduncle (the narrow part of the fish's body to which the tail fin is attached). Males also have distinctive breeding coloration, becoming intensely black dorsally with a bright red horizontal band and a white abdomen (Propst 1999, p. 49; Propst et al. 2001, p. 163).

Taxonomy

Evaluation of morphological (pertaining to the physical form and structure of the fish) and genetic information supports recognition of the Zuni bluehead sucker as being a valid subspecies distinct from both the Rio Grande sucker (Catostomus plebeius) and the bluehead sucker (C. discobolus) (Smith 1966, pp. 87–90; Smith et al. 1983, pp. 37–38; Crabtree and Buth 1987, p. 843; Propst 1999, p. 49). The Zuni bluehead sucker subspecies likely originated from a prehistoric geological event in which water of a Rio Grande tributary (where the Rio Grande sucker occurred) were brought into the headwaters of a Little Colorado River tributary (where the bluehead sucker occurred); this event caused the Rio Grande sucker and the bluehead sucker (which were formerly geographically isolated from one another) to come into contact and begin exchanging genes during the late Pleistocene (more than 1.1 million years ago) (Smith 1966, pp. 87–90; Smith et al. 1983, pp. 37–38; Unmack et al. 2014, p. 12). This process of the movement of a gene from one species into the gene pool of another species is known as introgression. Introgression results in a complex mixture of the parental genes in the offspring. In the case of the Zuni bluehead sucker, this genetic mixing of Rio Grande sucker genes with bluehead sucker genes occurred over an unknown length of time and created the distinct subspecies.

Current Range

The range of this species was formerly widespread within the Little Colorado and San Juan River drainages in Arizona and New Mexico. Over the years, the range-wide distribution of Zuni bluehead sucker has been reduced by over 90 percent (Service 2014). Factors contributing to these declines are habitat loss and degradation from sediment deposition related to wildfires, dewatering, impoundments, housing development, and nonnative predators, climate change impacts including reduced water availability and higher water temperatures continue to be a threat. The species' range has been significantly reduced, and the remaining habitat and populations are threatened by a variety of factors acting in combination to reduce the overall viability of the species. The risk of extinction is high because the remaining populations are small, isolated, and have limited potential for recolonization. This species is extremely vulnerable to environmental changes and cannot relocate without intervention by conservationists. Our ability to conserve the species is limited by lack of access to populations on private and tribal lands. (USFWS, 2020)

Critical Habitat Designated

Yes; 1/1/2015.

Legal Description

On June 7, 2016, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Catostomus discobolus yarrowi (Zuni bluehead Sucker) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in New Mexico (81 FR 36762-36785).

Critical Habitat Designation

The critical habitat designation for Catostomus discobolus yarrowi includes one CHU inMcKinley and Cibola Counties, New Mexico (81 FR 36762-36785).

Unit 1: Zuni River Unit, McKinley and Cibola Counties, New Mexico. (i) General description: Unit 1 consists of approximately 55.7 kilometers (km) (34.6 miles (mi)) of the Zuni River watershed and the adjacent floodplains within 91.4 lateral meters (300 lateral feet) on either side of bankfull discharge, except where bounded by canyon walls in McKinley and Cibola Counties, and is composed of land ownership by the State (2.1 km (1.3 mi)), Forest Service (19.5 km (12.1 mi)) and private landowners (34.0 km (21.1 mi)).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Catostomus discobolus yarrowi critical habitat consists of three components in New Mexico (81 FR 36762-36785):

(i) A riverine system with habitat to support all life stages of the Zuni bluehead sucker, which includes: (A) Dynamic flows that allow for periodic changes in channel morphology and adequate river functions, such as channel reshaping and delivery of coarse sediments. (B) Stream courses with perennial flows or intermittent flows that serve as connective corridors between occupied or seasonally occupied habitat through which the subspecies may disperse when the habitat is wetted. (C) Stream mesohabitat types including runs, riffles, and pools with substrate ranging from gravel, cobble, and bedrock substrates with low or moderate amounts of fine sediment and substrate embeddedness. (D) Streams with depths generally less than 2 meters (3.3 feet), and with slow to swift flow velocities less than 0.35 meters per second (1.15 feet per second). (E) Clear, cool water with low turbidity and temperatures in the general range of 2.0 to 23.0 °C (35.6 to 73.4 °F). (F) No harmful levels of pollutants. (G) Adequate riparian shading to reduce water temperatures when ambient temperatures are high and provide protective cover from predators.

(ii) An abundant aquatic insect food base consisting of fine particulate organic material, filamentous algae, midge larvae, caddisfly larvae, mayfly larvae, flatworms, and small terrestrial insects.

(iii) Areas devoid of nonnative aquatic species or areas that are maintained to keep nonnatives at a level that allows the Zuni bluehead sucker to continue to survive and reproduce.

Life History

Feeding Narrative

Adult: The primary source of food for Zuni bluehead sucker is periphytic algae (algae attached to rocks), which occurs mainly on cobble, boulder, and bedrock substrates with clean flowing water. Diet preferences have been described for adults, but not for the remaining life stages of Zuni bluehead sucker. Larval bluehead suckers (<25 mm (approx.1 in) total length) feed on diatoms (a type of algae), zooplankton (small floating or swimming organisms that drift with water currents), and dipteran larvae (true fly larvae) in stream areas with low velocity or in backwater habitats (Muth and Snyder 1995, p. 100). Juvenile and adult bluehead sucker are reported primarily to eat a variety of inorganic material, organic material, and bottomdwelling insects and other small organisms (Childs et al. 1998, p. 625; Osmundson 1999, p. 28; Brooks et al. 2000, pp. 66–69). Aquatic invertebrates are another important component of the Zuni bluehead sucker diet. These aquatic invertebrates have specific habitat requirements of their own. Both caddisflies and mayflies occur primarily in a wide variety of standing and running-water habitats with the greatest diversity being found in rocky-bottom streams with an abundance of oxygen (Merritt and Cummins 1996, pp. 126, 309). Caddisflies and mayflies feed on a variety of detritus, algae, diatoms, and macrophytes (aquatic plants) (Merritt and Cummins 1996, pp. 126, 309). Habitat that consists of rocky bottoms with periphytic algal growth is not only important to sustain aquatic invertebrate populations (a Zuni bluehead sucker food source), but also serves as a primary food resource of the Zuni bluehead sucker.

Reproduction Narrative

Adult: Zuni bluehead sucker spawn from early April to early June when water temperatures are 6 to 15 °C (43 to 59 °F), peaking around 10 °C (50 °F) (Propst 1999, p. 50; Propst et al. 2001, p. 164). Zuni bluehead sucker may have two spawning periods, with the majority of the spawning effort expended early in the season (Propst et al. 2001, p. 158).Females in spawning condition have been found over gravel beds (Sublette et al. 1990, p. 210; Propst et al. 2001, p. 158). Clean substrates free of excessive sedimentation are essential for successful breeding. Periodic flooding removes excess silt and fine sand from the stream bottom, breaks up embedded bottom materials, and rearranges sediments in ways that promote algae production and create suitable habitats with silt-free substrates.

Geographic or Habitat Restraints or Barriers

Adult: Seasonally dry channels and low waterfalls limit movement among headwaters.

Environmental Specificity

Adult: High

Tolerance Ranges/Thresholds

Adult: Low

Site Fidelity

Adult: High

Habitat Narrative

Adult: Zuni bluehead sucker typically inhabit small desert stream systems including isolated headwater springs, small headwater springs, and mainstem river habitats (Gilbert and Carman 2011, p. 2) with clean, hard substrate, flowing water, and abundant riparian vegetation. Periodic flooding removes excess silt and fine sand from the stream bottom, breaks up embedded bottom materials, and rearranges sediments in ways that promote algae production and create suitable habitats with silt-free substrates. Occupied pools often are edged by emergent aquatic vascular plants (e.g., willows, cattail) (Arizona Game and Fish Department 2002). Fry and young prefer shallow areas in backwaters or near the shore line (Arizona Game and Fish Department 2002). Clean substrates free of excessive sedimentation are essential for successful breeding. Degraded habitat consists of silt-laden substrates, high turbidity, and deep, stagnant water (Gilbert and Carman 2011, p. 6). Ponds formed by beaver dams and impoundments as well as pools formed during river intermittency create such degraded habitats.

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant

Dispersal

Adult: Larvae may move a short distance downstream.

Dispersal/Migration Narrative

Adult: This fish appears to be sedentary. Larvae may move a short distance downstream, and adults may stay in or near one pool throughout their adult life, only moving several meters upstream to spawn (D. Propst, NMDGF, pers. comm., cited by Carman 2004).

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

Unknown

Number of Populations:

6-20; with 5 "stable" populations

Population Size:

Arizona: 0-664 individuals between the years 2000 and 2012; New Mexico: unknown.

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Unknown

Adaptability:

Unknown, but likely low.

Population Narrative:

Zuni bluehead sucker distribution has been reduced by an estimated 95 percent in the last 30 years in New Mexico (Propst 1999, p. 51; NMDGF 2004, p. 15; Service 2014a, pers. comm.). The extent of potential range reduction in Arizona is not known. The entire Kinlichee Creek watershed encompasses approximately 47 km (29 mi) (Smith et al. 1983, p. 39; Crabtree and Buth 1987, p. 843; Hobbes 2000, pp. 9–16). It is unlikely that the entirety of the Kinlichee Creek watershed is occupied because the streams are susceptible to drying during drought. The number of Zuni bluehead sucker found in the Kinlichee Creek watershed in Arizona range from zero to 664 individuals between 2000 and 2012 (Hobbes 2000, pp. 9–16; Albert 2001, pp. 10–14; NMDGF et al. 2003, p. 6–10); David 2006, p. 35, Kitcheyan and Mata 2013, pp. 10–11). The subspecies is restricted to three isolated populations in the upper Rio Nutria watershed in west-central New Mexico (Carman 2008, pp. 2–3).

Threats and Stressors

Stressor: Water withdrawal
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Surface and groundwater withdrawal result in the direct loss of habitat as well as fragmentation of Zuni bluehead sucker habitat by reducing stream flow, spring flow, or water depth. Reduced stream velocities result in increased sedimentation, while overall loss of wetted habitat strands Zuni bluehead suckers in isolated shallow pools that may not provide suitable hard substrates for feeding and reproduction. Loss of appropriate habitat may decrease the reproductive success of Zuni bluehead sucker and result in mortality of individuals. Groundwater use in the range of the Zuni bluehead sucker is expected to increase due to human population expansion.

Stressor: Sedimentation
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Sedimentation occurs when particles suspended in the water column fall out of suspension and cover the streambed, filling in spaces between substrate particles. Sedimentation results in the loss of suitable habitat and available food resources for Zuni bluehead sucker. Fine sediments, in particular, reduce or prevent production of algae, the Zuni bluehead sucker's primary food. Research has shown that heavy sediment loads have the potential to limit algae production by restricting light penetration or smothering (Graham 1990, pp. 107–109, 113–114; Wood and Armitage 1997, pp. 203, 209–210). High concentrations of fine sediment have been

found to affect fishes: (1) By adversely affecting fish swimming and either reducing their rate growth, tolerance to disease, or even resulting in death (Bruton 1985, p. 221); (2) by reducing the suitability of spawning habitat and hindering the development of fish eggs, larvae and juveniles are more susceptible to suspended solids than adult fish (Chapman 1988, p. 15; Moring 1982, p. 297); (3) by modifying the natural migration patterns of fish (Alabaster and Lloyd 1982, pp. 2–3); (4) by reducing the abundance of food available to fish due to a reduction in light penetration (Bruton 1985, p. 231; Gray and Ward 1982, pp. 177, 183); and (5) by affecting the efficiency of hunting, particularly in the case of visual feeders (Bruton 1985, p. 221, 225–226; Ryan 1991, p. 207). If mobilized during the spawning season, fine sediments may also smother and suffocate spawned eggs (Propst and Hobbes 1996, p. 39). The reproductive successes of fishes that require clean gravel substrate have been reduced by increased sedimentation due to smothering of eggs, which may be the case for Zuni bluehead sucker (Berkman and Rabeni 1987, p. 285; Propst and Hobbes 1996, p. 38).

Stressor: Dams and impoundments
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Much of the primary water use from the Zuni River watershed is for irrigation of agriculture, livestock grazing, and human consumption. Many small impoundments, built primarily for watering livestock, partially prevent flows from reaching the mainstem rivers. According to Merkel (1979, p. 1), the lower Rio Nutria, Rio Pescado, and Zuni River watersheds have been drastically altered by human activities, such as the construction of many small impoundments for livestock watering. Reservoirs and diversion dams for irrigation have depleted stream flows below the dams and inundated stream reaches above the dams (Merkel 1979, p. 1; Hanson 1982, p. 4). Degradation of the upper watershed has led to increased sedimentation and many of the reservoirs are now only shallow, eutrophic (nutrient rich) ponds or wetlands with little or no storage capacity (NMDGF 2004, p. 20). Sediment trapping by these impoundments has also changed the character of the streams by altering channel morphology and substrate composition.

Stressor: Housing development
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Subdivision developments within the range of Zuni bluehead sucker would increase the amount of impervious surfaces in this watershed. Impervious surfaces are any surface material that prevents water from filtering into the soils, such as buildings, roads, sidewalks, patios, parking lots, and compacted soil (Brabec et al. 2002, p. 499, Coles et al. 2012, pp. 10, 107). An increase in the amount of impervious surfaces could increase the amount of runoff and decrease infiltration rates. Impacts of urbanization on stormwater runoff leads to various stressors on spring systems, including increased frequency and magnitude of high flows in streams, increased sedimentation, increased contamination and toxicity, and changes in stream morphology and water chemistry (Coles et al. 2012, pp. 1–3, 24, 38, 50–51). Urbanization can also impact aquatic species by negatively affecting their invertebrate prey base (Coles et al. 2012, p. 4). The increased frequency and magnitude of water flowing to streams combined with pollutant sources, such as sediment, nutrients, fertilizers, and other contaminants, have been linked to changes in stream hydrology, stream habitat, and degradation of the stream's biological

communities (Coles et al. 2012, p. 10). Urbanization can cause changes in fish population composition and distribution due to habitat changes and lower water table elevations due to groundwater use.

Stressor: Wildfire
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Wildfires can destroy vegetation along slopes and stream channels altering the physical properties of the soil. The lack of ground cover increases the amount of potential runoff, thereby increasing the amount of woody debris, sedimentation, and ash entering the stream (Swanston 1991, pp. 141, 175–177). Indirect effects, such as ash flow events that follow wildfire during monsoonal seasons can inundate Zuni bluehead sucker habitat, and smother and destroy eggs. Severe wildfires that extirpate fish populations are a relatively recent phenomenon and result from the cumulative effects of historical or ongoing overgrazing by domestic livestock, fire suppression, and climate change (Madany and West 1983, p. 666; Swetnam 1990, pp. 6–17; Touchan et al. 1995, p. 272; Swetnam and Baisan 1996, p. 28; Belsky and Blumenthal 1997, p. 318; Gresswell 1999, p. 212; Brown et al. 2004, p. 366; McKenzie et al. 2004, p. 898; Westerling et al. 2006, p. 943).

Stressor: Climate change
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Climate change could affect the Zuni bluehead sucker through increased temperatures, evaporation, and probability of long-term drought. However, there is uncertainty of how the indirect effects of climate change will affect Zuni bluehead sucker habitats due to a lack of information on the groundwater system that provides water to the species' spring-fed habitat and largescale projections of precipitation that contribute to stream flow. Climate change may be a significant stressor that indirectly exacerbates existing threats by increasing the likelihood of prolonged drought that would reduce water availability for streamflow or spring flow and incur future habitat loss.

Recovery

Recovery Actions:

- Not developed.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Continue cooperative efforts with all partners (U.S. Forest Service, New Mexico Department of Game and Fish, The Nature Conservancy, Zuni Tribe, and Navajo Nation) to annually monitor Zuni bluehead sucker populations and stream habitats. 2. Continue to collaborate with private landowners to assess additional sites within the Rio Nutria and Tampico drainages. 3. Identify and assess other potential areas within the Zuni bluehead sucker historical range, such as Little Water Canyon, to determine presence, evaluate current habitat conditions, and document any physical, biological, environmental, and chemical factors that may inhibit the species persistence. 4. Depending on the availability of suitable habitat conditions, consider using the captivereared population from the Albuquerque BioPark to extend or enhance the Zuni bluehead sucker current range. 5. Consider augmenting wild populations with captive-reared individuals from the Albuquerque BioPark; if appropriate. 6. Seek alternative captive refugia, such as Navajo Nation Tribal Hatchery, New Mexico Fish and Wildlife Conservation Office holding tanks, etc. that could serve as alternative sub-hatchery facilities to house Zuni bluehead sucker populations before the onset of catastrophic events. 7. Continue to monitor the encroachment of cattails in the Agua Remora and collaborate with Cibola National Forest to derive and implement strategic efforts to eradicate cattails in the Agua Remora reach. 8. Continue nonnative removal efforts of green sunfish in Agua Remora to alleviate predatory impacts to Zuni bluehead sucker. 9. Seek funding to aid with expenses associated with collection and analyses of Environmental DNA (eDNA) samples collected from various locations currently or historically occupied by Zuni bluehead sucker. 10. Consult with Zuni Fish and Wildlife Department to propose eDNA as an alternative nonlethal sampling technique on the Zuni Reservation. If approved and accepted by the Zuni Tribe, correspond with U.S. Forest Service to utilize their sampling protocol and techniques to collect water samples in Rio Pescado, Rio Nutria, and Zuni River to determine Zuni bluehead sucker presence. 11. Formulate an emergency contingency salvage plan for Zuni bluehead sucker, in case of catastrophic events (e.g., drought, fire, etc.). Such a plan would outline procedures and protocols for rescuing, handling, transporting, holding facility, lead agency, partner involvement, roles and responsibilities, funding, etc. 12. Formulate a Recovery Team composed of Tribal, State, Federal, and non-governmental partners) to develop a recovery plan for Zuni bluehead sucker. (USFWS, 2020)

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SPECIES ACCOUNT: *Catostomus santaanae* (Santa Ana sucker)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Threatened; April 12, 2000 (65 FR 19686).

Physical Description

Santa Ana suckers (Catostomus santaanae) are generally less than 16 centimeters (cm) (6.3 inches [in.]) in length; however, they have been collected at lengths up to 20.3 cm (8 in.). Their jaws have cartilaginous scraping edges inside the lips. Their color is silvery-white on the belly and dark gray on the sides and back, with irregular dorsal blotches on the sides and faint patterns of pigmentation arranged in lateral stripes. Membranes connecting the rays of the caudal (tail) fin are pigmented, but the anal and pelvic fins usually lack pigmentation. Spawning tubercles (raised growths on sexually mature fish), particularly at the beginning of the breeding season, are present on most parts of the body of breeding males and are heaviest on the anal fin, caudal fin, and lower half of the caudal peduncle (narrow region of body immediately in front of the caudal fin). Female suckers grow tubercles on the caudal fin and caudal peduncle. Their jaws have cartilaginous scraping edges inside the lips. There are 21 to 28 gill rakers on the external row of the first arch and 27 to 36 on the internal row (USFWS 2014).

Taxonomy

Santa Ana sucker is a small, short-lived member of the sucker family of fishes (Catostomidae)—so named primarily because of the downward orientation and anatomy of their mouth parts, which allow them to suck up algae, small invertebrates, and other organic matter with their fleshy, protrusible (extendable) lips. Santa Ana sucker was described in 1908 by Snyder as Pantosteus santa-anae from the Santa Ana River near Riverside, California. In 1966, the specific name was amended to eliminate the hyphen, and Pantosteus was relegated to a subgenus of Catostomus, which represented a new combination. Recent work has been conducted to investigate the phylogenetic relationships between suckers in western North America, but there is still some uncertainty regarding the where Catostomus santaanae would be placed. Currently, the taxonomic classification of Santa Ana sucker is Catostomus santaanae, which has not changed since it was listed (USFWS 2014).

Historical Range

The Santa Ana sucker’s historical range includes the rivers and larger streams in southern California emanating from the San Gabriel and San Bernardino mountains in Ventura, Los Angeles, Orange, Riverside, and San Bernardino counties, including the mainstems and tributaries from near the Pacific Ocean to the uplands of the Santa Ana River, Los Angeles River, and San Gabriel River watersheds. Information about the occurrence of the Santa Ana sucker in many tributaries within its historical range is incomplete; however, it is likely that the species’ historical distribution in the watersheds varied from year to year, depending on habitat suitability and access (for example, physical barriers or water availability) to these different areas. Thus, the distribution of the species expanded and contracted with changes in local conditions. Continuity between the main river channel and its tributaries allowed the species to vacate and recolonize areas in response to habitat suitability. Because historical data are not available to determine the upper limit of the species in each tributary, historical range is considered to extend throughout the watersheds where the in-stream gradient does not exceed 7 degrees. Santa Ana sucker was historically documented throughout the upper and lower portions of the Santa Ana River watershed, including the mainstem from near the current location of Seven Oaks Dam to approximately 22.5 kilometers (km) (14 miles [mi.]) below Prado Dam; and multiple tributaries, including City Creek, Warm Creek, Lytle Creek, Rialto Channel, Evans Lake drain, Tequesquite Arroyo, Sunnyslope Creek, Anza Park drain, and Chino Creek. Santa Ana sucker was historically documented throughout the upper and lower areas of the Los Angeles River watershed, including the mainstem Los Angeles River near Universal City and Los Feliz Boulevard and the tributaries Big Tujunga Creek and Arroyo Seco Creek. Santa Ana sucker was historically documented throughout the upper and lower portions of the San Gabriel River watershed, including the mainstem San Gabriel River near Fish Canyon, Fish and Fern Canyon, Rio Hondo, San Jose Creek, West Fork, Bear Creek, North Fork, East Fork, Cattle Canyon Creek, and San Dimas Wash (USFWS 2014).

Current Range

The listed entity is found in three watersheds in Southern California: (1) the Santa Ana River in San Bernardino, Riverside, and Orange Counties; (2) the San Gabriel River in Los Angeles County; and (3) Big Tujunga Creek, a tributary to the Los Angeles River, in Los Angeles County. The species also occurs in the Santa Clara River watershed (USFWS, 2023).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 2/26/2004.

Legal Description

On December 14, 2010 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Catostomus santaanae (Santa Ana sucker) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes three critical habitat units (CHUs) (six sub-units) in California (75 FR 77962-78027).
The critical habitat designation for Catostomus santaanae includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Catostomus santaanae.

Critical Habitat Designation

The critical habitat designation for Catostomus santaanae includes three CHUs (6 total subunits) which encompass approximately 9,331 acres in San Bernardino, Riverside, Los Angeles and Orange Counties, California (75 FR 77962-78027).

Unit 1 is located in San Bernardino, Riverside, and Orange Counties and consists of three subunits totaling 7,097 ac (2,872 ha) of Federal (U.S. Army Corps of Engineers and USFS), local government, and private land (Table 2). The purpose of this unit is to independently support a population of Santa Ana sucker in a functioning hydrologic system that provides suitable water quality, supply, and coarse sediment. One currently unoccupied subunit (Subunit 1A) provides essential sources of water and coarse sediment to occupied portions of the unit.

Subunit 1A: Upper Santa Ana River - Subunit 1A is located near the Cities of Highland, Mentone, and Redlands in San Bernardino County, California. This subunit includes: 7 mi (12 km) of City Creek (measured from its confluence with the Santa Ana River), 12 mi (19 km) of Mill Creek (measured from its confluence with the Santa Ana River), and 10 mi (17 km) of the Santa Ana River from below the Seven Oaks Dam to near Tippecanoe Avenue. The lower portion of the Santa Ana River below its confluence with City and Mill Creek is adjacent to urban development, while the upstream portions of City Creek and Mill Creek are in the San Bernardino National Forest. Lands in this subunit are under Federal (USFS and Bureau of Land Management (BLM)) (74 ac (111 ha)), State/Local (95 ac (38 ha)), and private (1,389 ac (562 ha)) ownership (Table 2). Subunit 1A is outside the geographical area occupied by the species at the time of listing and is not currently occupied. While City Creek and the Santa Ana River above Tippecanoe Avenue are not currently occupied, these areas were historically occupied based on a 1982 California Natural Diversity Database record and a 1940 University of Michigan Museum of Zoology Fish Collection (UMMZ) database record, respectively, and City Creek currently provides suitable habitat conditions for Santa Ana sucker (OCWD 2009, pp. 5–71–5–76). Mill Creek is not known to be historically or currently occupied and does not provide suitable habitat conditions for Santa Ana sucker; however, we determined this area to be essential for the conservation of the species because of the process of water and coarse sediment transport that it provides. The Santa Ana River above Tippecanoe Avenue, Mill Creek, and City Creek provide stream and storm waters (PCE 1) which are necessary to transport coarse sediments necessary to maintain preferred substrate (PCE 2) conditions in occupied portions in the Santa Ana River and we determined that these areas are essential for the conservation of the species because of the process of water and coarse sediment transport that they it provide. The creation and operation of Seven Oaks Dam has regulated water flow and impeded the transport of coarse sediment. However, because the operation of Seven Oaks Dam, in coordination with Prado Dam downstream, is currently permitted for flood control operations only (operations only regulate flows throughout the year in an effort to prevent catastrophic flow events downstream) and not for water storage purposes (Service 2002, pp. 3–6), the flow of water through the dam still provides water necessary for occupied reaches of the Santa Ana River downstream. Storing water for the purpose of water conservation (i.e., diversions or storage for water sales) is not currently authorized, nor was proposed as a purpose for Seven Oaks Dam (Service 2002, p. 5). Although there has recently been a CRWQCB decision to allow up to 200,000 acre-feet to be diverted from the Seven Oaks Dam reservoir, this potential action has not been evaluated or approved by the Federal agencies involved. The CRWQCB stated that water conservation operations will be the responsibility of the water agency and the appropriate Federal agencies will need to be consulted before water can be diverted for water conservation (i.e., sale) purposes (CRWQCB 2009, p. 23). As stated above, this subunit is relatively unmodified compared to the other subunits in this unit, with the exception of the upper Santa Ana River that contains Seven Oaks Dam and the lower portion of City Creek that is adjacent to urbanized areas. The critical habitat designated in this subunit is threatened by impacts associated with, but not limited to, water diversion, dams, operation of hydro-electrical power facilities, or alteration of streambeds. We consider the magnitude of threats to be less severe than those in the lower watershed because the majority of the subunit is relatively unmodified and portions are within the San Bernardino National Forest. Nonetheless, we also recognize that active management and special management considerations or protection may be needed in this subunit (see Special Management Considerations or Protection section above). Although areas of the Santa Ana River above South La Cadena Drive and some of its associated tributaries generally dry during the summer, portions of the upper Santa Ana River system (within San Bernardino County) have a higher gradient and a greater percentage of gravel and cobble substrate than the occupied areas that are downstream (Warrick and Rubin 2007, pp. 1–2). Santa Ana suckers spawn over gravel substrates, where their eggs can adhere to gravel before hatching into larvae. Flood events or high winter flows from upstream areas annually replenish this coarse substrate and clean sand and silt from it (Kondolf 1997, pp. 533–535). Additionally, Santa Ana suckers feed by scraping algae, insects, and detritus from gravel and cobble. Therefore, the spawning and feeding substrates (gravel and cobble) which are replenished by upstream sources are essential to the reproductive ability and development of Santa Ana suckers in the downstream occupied reaches (Kondolf 1997, pp. 533–535, 536–537). The section of the Santa Ana River from above Tippecanoe Avenue in San Bernardino, City Creek, and Mill Creek (although not currently occupied) have become particularly essential for the conservation of the species since the Seven Oaks Dam has reduced the transport of coarse sediment and altered the natural flow in the downstream, occupied areas of the Santa Ana River. They are in fact the primary sources of coarse sediment in the upper Santa Ana River watershed (PCE 2) and additionally are part of the Santa Ana River hydrologic system (PCE1), and assist in maintaining water quality (PCE 4) and temperature (PCE 5) to occupied reaches of the Santa Ana River; therefore, these areas are essential for the conservation of Santa Ana sucker (see Sites for Breeding, Reproduction, and Rearing (or Development) of Offspring section above). In our process of determining what areas meet the criteria of occupied critical habitat, it became apparent that habitat and hydrological modifications that have been occurring for many years in the Santa Ana River have decreased the areas suitable for occupation by the Santa Ana sucker (Moyle 2002, p. 184; Thompson et al. 2010, p. 330). The presence of two large dams operating in coordination have altered and will continue to alter the flow of water and coarse sediments in the Santa Ana River (Chang 2000, p. 3) that are necessary for essential life cycle processes of Santa Ana sucker. Specifically, the models used to predict the transport of sediment throughout the Santa Ana River and surveys have confirmed that sediment has been significantly degraded in the Santa Ana River from the E Street USGS gauge (#11059300) to the Metropolitan Water District crossing USGS gauge (#11066460) and deposited above and below these areas (Humphrey et al. 2004, pp. 6–7). The deposition and degradation of sediments throughout the Santa Ana River will eventually level the gradient of the Santa Ana River between the Seven Oaks and Prado Dams. This ongoing process, which modifies and degrades the Santa Ana sucker's habitat, highlights the importance of designating areas that provide for essential processes, such as water and coarse sediment transport to occupied areas downstream. Therefore, we have determined that City Creek, Mill Creek, and the Santa Ana River above Tippecanoe Avenue are essential for the conservation of the species because they provide for essential processes, such as water and coarse sediment transport.

Subunit 1B: Santa Ana River - Subunit 1B is located near the cities of Colton and Rialto in San Bernardino County and the cities of Riverside, Norco, and Corona in Riverside County, California. This subunit includes approximately 22 mi (35 km) of the mainstem of the Santa Ana River from near Tippecanoe Avenue in San Bernardino County to the Prado Dam and Flood Control Basin in Riverside County. This subunit also includes sections of the following tributaries (distances are measured from the mainstem of the Santa Ana River): 1,647 ft (502 m) of the Rialto Drain and 2,413 ft (736 m) Sunnyslope Creek. Lands within this subunit are under Federal (U.S. Army Corps of Engineers) (521 ac (211 ha)), State/Local (2,854 ac (1,155 ha)), and private (1,396 ac (565 ha)) ownership (Table 2). Areas within this subunit are within the geographical area occupied by the species at the time of listing, most are currently occupied, and all contain physical and biological features essential to the conservation of the species and may require special management considerations or protection. An approximate 5.1-mile (8.1-km) portion of the Santa Ana River between La Cadena Drive and Tippecanoe Avenue within Subunit 1B is not currently occupied due the barrier to upstream dispersal at La Cadena Drive; however, this areas was considered occupied at the time of listing and is essential to the conservation of the species and contains sources of water and coarse sediment (PCE 1) essential to the conservation of Santa Ana sucker. This subunit has been heavily impacted by urban development and threats to Santa Ana sucker and its essential features in this subunit result from impacts associated with, but not limited to: Water diversion; dams; water quality impacts from non-point source and point source pollution (including untreated urban run-off and discharge of treated wastewater); and altered hydrology throughout the watershed (including alterations from instream barriers, construction of bridges, channelization, and other flood control structures). Special management considerations or protection may be needed in this subunit to protect its essential features (see Special Management Considerations or Protection section above). Recent surveys found Santa Ana suckers at various locations in the mainstem of the Santa Ana River between the Rialto Drain and the Prado Dam (Baskin et al., 2005, pp. 1–2; Swift 2009, pp. 1–3). Santa Ana suckers also occupy the Rialto Drain and Sunnyslope Creek at least during portions of the year (Chadwick Ecological Consultants, Inc. 1996, p. 9; Swift 2000, p. 8; Swift 2001, p. 45). At this time, the low-flow channel of the Santa Ana River has moved away from its confluence with Sunnyslope Creek, and accumulated sediments and vegetation are preventing access to this creek by Santa Ana suckers (OCWD 2009, pp. 5–31). However, a connection between the mainstem and Sunnyslope Channel will likely be reestablished following a highflow event. Santa Ana suckers were found upstream of the Rialto Drain in the vicinity of the La Cadena Bridge drop-structure during spring-time flow releases from the Seven Oaks Dam in 2005 (Baskin et al. 2005, p. 1). However, the La Cadena Bridge drop-structure currently acts as a barrier to upstream migration at all flow levels. Rialto Drain and Sunnyslope Creek are the only tributaries to the Santa Ana River in this subunit where Santa Ana sucker spawning has been documented. However, the distribution of fry and juvenile fish observed in various locations within the mainstem is a strong indication that spawning areas other than the Rialto Drain and Sunnyslope Creek likely exist within the Santa Ana River. In the mainstem of the Santa Ana River, dry-season flows are dependent primarily on discharges from tertiary wastewater treatment plants and upwelling of ground water within the Unit (CRWQCB 1995, pp. 1–4–1–8; Chadwick and Associates, Inc. 1992, p. 20), while storm-season flows are regulated by the upstream Seven Oaks Dam. The discharge of treated wastewater effluent maintains stream volume and velocity within the mainstem and the Rialto Drain to maintain habitat patches that support the riverine environment (PCE 1) necessary for Santa Ana sucker. However, it appears that these wastewater flows are not sufficient to deliver coarse sediment downstream (Thompson et al. 2010, pp. 327–328). The discharge of treated wastewater effluent along with the upwelling of groundwater also lowers instream water temperature to some extent in portions of the Santa Ana River (Chadwick and Associates, Inc. 1992, p. 26) (PCE 5), and rising groundwater in the Riverside Narrows feeds several small tributaries to the Santa Ana River, including the Sunnyslope Creek (CRWQCB 1995, pp. 1–4–1–8; Swift 2001, p. 3) (PCE 1). Rialto Drain and Sunnyslope Creek contain gravel and cobble substrate, with some sand accumulation along channel edges and deep pools, and a riparian overstory (PCEs 2 and 6). Therefore, these areas provide areas for spawning and rearing of fry and juvenile fish (PCE 1) and shallow-water refuge for Santa Ana suckers during storms and during periods of high ambient air temperatures (PCE 6). Almost all other tributaries to the Santa Ana River in this subunit have been channelized, and while these tributaries continue to provide some water and storm water flows to the mainstem, the majority of this water is untreated run-off from surrounding urban areas. Also, with the exception of their confluence with the mainstem, it appears these other tributaries to the Santa Ana River have been modified such that they no longer provide suitable habitat for the species. In addition to reduced water quality and altered hydrology, habitat within this subunit has been impacted by the construction of several bridges spanning the Santa Ana River and grade-control structures that fragment habitat for Santa Ana sucker. Therefore, the physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats associated with water diversion, alteration of stream channels and watersheds, and reduction of water quantity and quality associated with urban development. Please see Special Management Considerations or Protection section for further discussion of the threats to Santa Ana sucker habitat.

Subunit 1C: Lower Santa Ana River - Subunit 1C is located near the City of Corona in Riverside County and the cities of Anaheim and Yorba Linda in Orange County, California. This subunit includes approximately 10.7 mi (17.2 km) of the Santa Ana River mainstem from below the Prado Dam outlet in Riverside County to 0.6 mi (1.03 km) downstream of the State Route 90 (Imperial Highway) Bridge in Orange County. Tributaries to the Santa Ana River in this subunit may provide water and storm water flows necessary to maintain preferred substrate conditions in the occupied portion of the Santa Ana River (PCE 1). However, we do not currently have information on the extent of their contribution and therefore are not proposing any tributaries to the Santa Ana River in Subunit 1C as critical habitat. Lands within this subunit are under State/Local (56 ac (23 ha)) and private (711 ac (288 ha)) ownership (Table 2). All areas in Subunit 1C are within the geographic area occupied by the species at the time of listing and contain the features essential to the conservation of the species and may require special management considerations or protection. This species has been found in the vicinity of the Gypsum Canyon Bridge, Weir Canyon drop structure, and the Imperial Highway overpass (Chadwick Ecological Consultants, Inc. 1996, p. 9; Swift 2000, pp. 15–20; Baskin and Haglund 2001, pp. 1–5). More recently Santa Ana suckers were collected just below Prado Dam (SMEA 2008, p. 1; Lovan 2010, pers. comm.). This subunit has been heavily impacted by urban development and threats to Santa Ana sucker and its essential features in this subunit result from impacts associated with, but not limited to: Water diversion; dams; water quality impacts from non-point source and point source pollution (including untreated urban run-off and discharge of treated wastewater); and altered hydrology throughout the watershed (including alterations from instream barriers, construction of bridges, channelization, and other flood control structures). We also recognize that special management considerations or protection may be needed in this subunit to protect its essential features (see Special Management Considerations or Protection section above). Upstream water flows to Subunit 1C are primarily maintained by releases from Prado Dam, a structure that has altered the hydrology of the system, resulting in fluctuating water (PCE 1) and sediment (PCE 2) releases. The numerous tributaries flowing into the Santa Ana River below Prado Dam appear to contribute little dry-season flow. Releases from Prado Dam maintain perennial stream flow in the Santa Ana River, which in turn maintains well defined banks supporting native riparian vegetation (PCE 6) and deep pools (PCE 2). However, since the velocity is typically high, water released below the dam is often turbid. During storms, water containing fine sediments passes over or through a dam, and because sediments remain suspended within the reservoir pool for several months, downstream turbidity can be increased (PCE 4) (Ally 2004a, p. 36). Releases of turbid water could also degrade downstream foraging and spawning habitat if areas become covered by fine silts. The operation of Prado Dam also traps larger sediments therefore decreasing the deposition of gravel and cobble needed to maintain spawning and foraging habitat below the dam. In addition to reduced water quality and altered hydrology, habitat within this subunit has been impacted by the construction of several bridges spanning the Santa Ana River that have constricted or redirected the stream channel in many places. Therefore, the physical and biological features essential to the conservation of the species in this subunit may require special management considerations or protection to address threats from water diversion, alteration of stream channels and watersheds, and reduction of water quantity and quality associated with urban development. Please see the Special Management Considerations or Protection section of this final rule for discussion of the threats to the Santa Ana sucker habitat.

Unit 2: San Gabriel River - Unit 2 consists of the West, North, and East Forks of the San Gabriel River upstream of the San Gabriel Reservoir, in Los Angeles County, California. This unit includes 9.3 mi (14.9 km) of the West Fork downstream of Cogswell Dam to the San Gabriel Reservoir, 3.2 mi (5.2 km) of the North Fork upstream from the confluence with the West Fork, and 10.4 mi (16.7 km) of the East Fork downstream of the Bridge-of-No-Return to the San Gabriel Reservoir. This unit also includes sections of the following tributaries (distances are measured from the mainstem of the fork): 0.3 mi (0.5 km) of Big Mermaids Canyon Creek and 3.3 mi (5.3 km) Bear Canyon Creek, both tributaries of the West Fork; 0.2 mi (0.2 km) of the West Fork of Bear Canyon Creek, a tributary of Bear Canyon Creek; 1.5 mi (2.4 km) of Bichota Canyon Creek, a tributary of the North Fork; 3.8 mi (6.2 km) of Cattle Canyon Creek, a tributary of the East Fork; and 0.6 mi (0.9 km) of Cow Canyon Creek, a tributary of Cattle Canyon Creek. Lands within this unit are entirely within the Angeles National Forest and are under Federal (USFS) (917 ac (371 ha)) and private (83 ac (34 ha)) ownership (Table 2). All areas in Unit 2 are within the geographical area occupied by the species at the time of listing, contain the features essential to the conservation of the species and may require special management considerations or protection. Unit 2 is the only unit designated as critical habitat that, overall, has a sediment transport and hydrological regime existing in a nearnatural state. The function of Unit 2 is to independently support a population of Santa Ana sucker within a relatively intact watershed that provides good water quality and supply, and sediment transport. The Santa Ana suckers in this unit are the only extant population of the species that is not chronically exposed to urban runoff or tertiarytreated wastewater discharges. Additionally, this unit does not have a regulated water supply (with the exception of the West Fork of the San Gabriel River). However, threats to Santa Ana sucker and its essential features in this unit result from impacts associated with, but not limited to: Water diversion; dams; water quality impacts as a result of increased run-off due to a recent, intense wildfire event; and recreational use impacts from OHVs or other recreational uses on National Forest lands. We also recognize that special management considerations or protection may be needed in this subunit to protect its essential features (see Special Management Considerations or Protection section above). In addition to surveys discussed in the listing rule (65 FR 19686; April 12, 2000) and in the previous designation of critical habitat for Santa Ana sucker (70 FR 425; January 4, 2005), additional surveys have documented Santa Ana suckers in the West, North, and East Forks of the San Gabriel River and the following tributaries: Big Mermaids Canyon, Bear Canyon, Bichota Canyon, Cattle Canyon, and Cow Canyon Creeks (Haglund and Baskin 1992, p. 32; O’Brien 2009a, pp. 2–3; Ally 2004b, pp. 8–9, 14–15, 22, 24–25, 28; Ally 2004c, pp. 9–10, 13–14, 16–17; Tennant 2004, pp. 5–8; Tennant 2006, p. 3). The West, North, and East Forks of the San Gabriel River have one of the most intact native freshwater fish faunas in Southern California (Haglund and Baskin 2003, p. 7), have good water quality, and appear to support the highest abundance of Santa Ana suckers within the species’ range. Natural water flow in the North and East forks, and the tributaries included in this unit, is unimpeded by large-scale dams. However, water flows in the West Fork of the San Gabriel River are affected by Cogswell Dam, a structure that has altered the hydrology of the system, resulting in fluctuating water (PCE 1) and sediment (PCE 2) releases. During its operational life, the Cogswell Reservoir has accumulated a large volume of sediment behind the dam that affects the quality of water released both through operations and unavoidable, uncontrolled leakage (Ally 2004a, p. 1). During the summer months, the only flow into the West Fork of the San Gabriel River is the result of leakage from the dam, and because flow velocities are low, sediments do not travel far downstream (Ally 2004a, p. 36). During storms, water containing fine sediments passes over or through the dam, and because sediments remain suspended within the reservoir pool for several months, downstream turbidity may be increased over usual conditions (PCE 4) (Ally 2004a, p. 36). Previous releases from Cogswell Dam containing more than 200,000 cubic yards (152,911 cubic meters) of silt and other sediment have severely impacted the habitat of the West Fork of the San Gabriel River and San Gabriel Reservoir (Drake 1988, p. 7; Haglund and Baskin 1992, p. 57; Moyle and Yoshiyama 1992, p. 204; Moyle et al. 1995, p. 203; Moyle 2002, p. 184). These rapid increases in flow volume and velocity along with sediment sluicing may disrupt Santa Ana sucker spawning and flush juvenile Santa Ana suckers into areas with unsuitable habitat. Along with impacts associated with the operation of Cogswell Dam, habitat within Unit 2 has also been impacted by recreational activities, including OHV use and the construction of recreational dams. Authorized OHV activity occurs in the USFS's San Gabriel Canyon OHV Area at the junction of the East, North, and West Forks. The use of the river as an OHV recreational area may result in adverse effects to Santa Ana sucker by increasing turbidity (PCE 4); disrupting the physical structure of habitat for spawning, resting, and feeding (PCE 2); and introducing pollutants (such as oil and gas) into streams (PCE 4) (65 FR 19686; April 12, 2000). To minimize impacts to Santa Ana sucker from OHV use, the USFS has implemented protection measures (such as establishing designated stream crossings and limiting the number of stream crossings in the OHV area) (Service 2005b, p. 8). The construction of ''recreational'' dams degrades instream and possibly bank habitat, increases turbidity (PCE 4), and disrupts sediment transport. Over 500 recreational dams were found in 2001 and 2002 within a 7.1–mi (11.4–km) reach of the East Fork of the San Gabriel River (Ally 2001, p. 2; Ally 2003, pp. 1–2). Recreational dams are constructed on a frequent basis in the San Gabriel Canyon OHV Area in the North Fork of this river as well (USFS 2008, p. 6). Therefore, the physical and biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats associated with water diversion, alteration of stream channels and watersheds, and human recreational activities. Unit 2 was not directly impacted by the 2009 Station Fire that burned approximately 161,000 ac (64,975 ha) of lands in the San Gabriel Mountains (USFS 2009, p. 4), although indirect impacts associated with post-fire debris flow and changes to water quality may have occurred or could occur in the future. Because this particular area did not burn in the Station Fire, it was not analyzed in the U.S. Geological Survey (USGS 2009) or USFS (2009) reports; however, the burned area is directly adjacent to the West Fork of the San Gabriel River and thus may have some impact to critical habitat. For additional information on this fire and its anticipated impacts, see the Unit 3: Big Tujunga Creek section below. Please see Special Management Considerations or Protection section of this final rule for discussion of the threats to Santa Ana sucker habitat.

Unit 3: Big Tujunga Creek - Unit 3 includes a total of 1,233 ac (499 ha) of land and consists of two subunits located in Los Angeles County, California. Lands within this unit are under Federal (USFS) (286 ac (116 ha)) and private (947 ac (384 ha)) ownership (Table 2). The purpose of this unit is to independently support a population of Santa Ana sucker in a functioning hydrologic system that provides suitable water quality and supply, and coarse sediments. One of the two subunits in Unit 3, Subunit 3B is outside of the geographic range occupied by the species at the time of listing but provides essential sources of water and sediment to the occupied subunit (3A) within the unit. In August 2009, the Station Fire began and eventually burned approximately 161,000 ac

(64,975 ha) of lands within the San Gabriel Mountains (USFS 2009, p. 4). The fire burned conifer forests, chaparral, and riparian vegetation in the stream corridors, including approximately 81 mi (130.36 km) of perennial channel and 572 mi (920.54 km) of intermittent stream beds (USFS 2009, p. 2). As a result of this fire, excessive debris flows and changes to water quality are anticipated to occur during seasonal rains over the next several years. The greatest potential for significant impacts resulting from elevated debris flows is anticipated in Big Tujunga Canyon, Pacoima Canyon, Arroyo Seco Canyon, the West Fork of the San Gabriel River, and Devil's Canyon (USFS 2009, p. 4). The estimated debris flow probability for a 3-hour duration, 1-year-reoccurence thunderstorm in the area impacted by the Station Fire indicates an 81 to 100 percent probability for impact to critical habitat in all of Unit 3 (USGS 2009, p. 9, Fig 3A). Anticipated post-fire impacts to streams within this unit include ash and debris deposition that may physically alter streambeds and pools, increased scouring of riparian and aquatic vegetation, and increased water temperature from the short-term loss of canopy shading (USFS 2009, p. 5). Changes to water quality (such as increased turbidity) are also anticipated from both post-fire impacts and from the release and mobilization of toxic chemicals such as gas, oil, and building materials as a result of burned structures and their contents (USFS 2009, p. 6). The USFS determined that the future combined impacts attributed to the Station Fire may lead to a temporary loss or reduction of suitable stream habitat and a localized risk of extirpation that may result in threatening the viability of Santa Ana sucker (USFS 2009, p. 7). Additionally, the loss of vegetation and creation of roads for firefighting may allow greater access to streambeds and facilitate increased OHV use, resulting in further habitat degradation (USGS 2009, p. 7).

Subunit 3A: Big Tujunga and Haines Creeks - Subunit 3A includes an approximately 13–mi (21–km) stretch of Big Tujunga Creek (a tributary of the Los Angeles River) between the Big Tujunga Dam and Reservoir and Hansen Dam and Flood Control Basin. This subunit also includes Haines Creek, a small stream within the floodplain of Big Tujunga Creek. The 1,189 ac (481 ha) of land within this subunit is under Federal (USFS) (242 ac (98 ha)) and private (947 ac (384 ha)) ownership (Table 2). All areas of Subunit 3A are within the geographical area occupied by the species at the time of listing and contain the features essential to the conservation of the species which may require special management considerations or protection. This subunit has been heavily impacted by urban development. Threats to Santa Ana sucker and its essential features in this subunit result from impacts associated with, but not limited to: Water diversion; dams; Water quality impacts from non-point source and point source pollution (including untreated urban run-off and discharge of treated wastewater); and altered hydrology throughout the watershed (including alterations from instream barriers, construction of bridges, channelization and other flood control structures). We also recognize that special management considerations or protection will be required in this subunit to protect its essential features (see Special Management Considerations or Protection section above). In addition to surveys cited in the listing rule (65 FR 19686; April 12, 2000) and in the previous designation of critical habitat for Santa Ana sucker (70 FR 425; January 4, 2005), other surveys have documented Santa Ana suckers in Big Tujunga Creek between Delta Flats and Vogel Flats (Haglund and Baskin 2001, pp. 2–4; O'Brien 2009b, p. 2), and in the Big Tujunga Wash Mitigation Bank, including Haines Creek (Chambers Group 2004, pp. 6–3, 6–4). There has been previous speculation that Big Tujunga Creek between the Big Tujunga Dam and Big Tujunga Canyon Road Bridge may no longer be occupied by Santa Ana sucker; however, recent surveys indicate that Santa Ana suckers are present in this area but in relatively low abundance (Haglund and Baskin 2010, pp. 17–18). Swift (2002, p. 3) speculates that streambed characteristics in three places upstream of Big Tujunga Canyon Road Bridge may prevent upstream movement or make movement possible only during rare high flow events. We currently consider this area occupied because Santa Ana suckers have been documented near and downstream of the Big Tujunga Canyon Road Bridge and because we do not have evidence of the existence of barriers permanently precluding upstream movement to the dam. The upstream sections of Big Tujunga Creek are also important for providing stream and storm waters necessary to transport coarse sediments to maintain preferred substrate conditions (PCE 2) for Santa Ana sucker in occupied areas downstream. A section of Haines Creek upstream of the Foothill Bridge traverses the Angeles National Golf Course. This 160-ac (65 ha), privately-owned golf course lies between the confluence of Big Tujunga and Haines Creeks and includes the alluvial floodplain and multiple lowflow channels that traverse the golf course. Periodic high storm flows from the Big Tujunga Creek travel through the golf course into Haines Creek on an irregular basis and likely provide the only source of stream and storm waters necessary to transport coarse sediments (from Big Tujunga Creek) to maintain preferred substrate conditions (PCE 2) to the occupied portion of Haines Creek (Chambers Group 2004, p. 6–4). Therefore, the alluvial floodplain and multiple low-flow channels that traverse the golf course are essential to the conservation of the species because they provide the primary (and potentially the sole) source of stream and storm waters (PCEs 1, 4, and 7) downstream into the Big Tujunga Wash Mitigation Bank that supports Santa Ana sucker (see Summary of Changes From Previously Designated Critical Habitat section above for more discussion of the area designated as critical habitat on the Angeles National Golf Course). The upstream portion of this subunit is within the Angeles National Forest and is therefore not exposed to the effects of urbanization. However, the downstream portion of Big Tujunga Creek between the Oro Vista Bridge and Hansen Dam is adjacent to existing urban development south of the creek, which has altered water flows transporting coarse sediment (PCE 2) into the Big Tujunga Creek. Several tributaries (including the upper portion of Haines Creek) that flow into Big Tujunga Creek through the communities of Sunland and Tujunga have been channelized through urbanized areas for flood control purposes. This channelization has eliminated habitat for Santa Ana sucker, altered the hydrologic regime (PCE 1), and reduced the transport of sediments needed to maintain channel substrate conditions (PCE 2) in the occupied sections of Big Tujunga Creek. Habitat in Subunit 3A has been altered due to the operation of the Big Tujunga Dam upstream and Hansen Dam downstream. All flows in the occupied reaches of Big Tujunga Creek are moderated by the operation of Big Tujunga Dam, which has eliminated flows along most of the creek during late summer and autumn of dry years (Palavido et al. 2008, p. 8), thereby reducing not only the amount of water (PCE 1) entering the system but also the amount of coarse sediment (PCE 2) being transported downstream. During these dry periods, Santa Ana suckers are restricted to an approximate 1-mi (1.6- km) section of the creek (Palavido et al. 2008, p. 8). At times, the creek can be reduced to a series of standing pools with only a trickle of flow between them (Swift 2002, p. 1), further isolating Santa Ana suckers (PCE 1). To minimize impacts to the species, a strategy is being developed with the objective of maintaining and enhancing Santa Ana sucker habitat within the lower Big Tujunga Creek (Mendez 2005, p. 1). Habitat within this subunit has also been impacted by the construction of several bridges (such as the Foothill, Interstate-210, and Oro Vista bridges). The habitat that serves as a connective corridor (PCE 7) within both Big Tujunga Creek and Haines Creek as they flow under the Foothill and Interstate- 210 bridges is often temporarily fragmented during periods of low flow (Swift 2006a, p. 2). Hence, sufficient water flow from the upstream dam is necessary to ensure water and coarse sediment transport to maintain the stream channel substrate conditions required by Santa Ana sucker in this area (PCEs 1, 2, and 7). The physical and biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats associated with water diversion, alteration of stream channels and watersheds, and human recreational activities. Please see Special Management Considerations or Protection section of the 2009 proposed rule and this final rule for discussion of the threats to Santa Ana sucker habitat.

Subunit 3B: Gold, Delta, and Stone Canyon Creeks - Subunit 3B consists of three tributaries to Big Tujunga Creek (measured from their confluence with the mainstem): A 1.89-mi (3.04-km) section of Gold Canyon Creek, a 0.79-mi (1.27-km) section of Delta Canyon Creek, and a 0.67-mi (1.08-km) section of Stone Canyon Creek. The 44 ac (18 ha) of land within this subunit is entirely within the Angeles National Forest and is entirely under Federal (USFS) ownership (Table 2). The three tributaries in this Subunit 3B are not within the geographical range of the species occupied at the time of listing and are not currently occupied, but are included in this critical habitat designation because they contribute essential coarse sediments and flows to occupied habitats downstream (PCEs 1 and 2). This subunit has been impacted by urban development, although to a lesser extent than the mainstem of Big Tujunga Creek. Threats to the critical habitat designated in this subunit result from impacts associated with, but not limited to, water diversion, dams, and altered hydrology in the lower portion of the watershed. We also recognize that special management considerations or protection may be required in this subunit (see Special Management Considerations or Protection section above). While we are not aware of any surveys for Santa Ana sucker conducted in Gold Canyon, Delta Canyon, or Stone Canyon Creeks, it appears that the slopes of Delta Canyon and Stone Canyon Creeks from near their confluence with Big Tujunga Creek are too steep to be passable by Santa Ana sucker. The slope of Gold Canyon Creek from approximately 0.49 mi (0.8 km) from its confluence with Big Tujunga Creek also appears to be too steep to be passable by Santa Ana sucker. Please see the Criteria Used To Identify Critical Habitat section of this final rule for a discussion of how we determined the slope within these creeks. These tributaries are particularly essential for the conservation of the species given the extent to which the hydrology and the habitat of the downstream occupied section of Big Tujunga Creek has been altered and degraded due to the construction and operation of Big Tujunga Dam. These creeks are essential for the conservation of the species because they provide and transport coarse sediment (PCE 2) and convey stream flows and flood waters (PCE 1) necessary to maintain habitat conditions for the downstream occupied areas of Big Tujunga Creek. The areas of these creeks at their confluence with Big Tujunga Creek also provide protective areas for juvenile Santa Ana suckers during high flow events, during periods of high ambient temperatures, and from predators (PCEs 1 and 6).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Catostomus santaanae critical habitat consists of seven components (75 FR 77962-78027):

(1) A functioning hydrological system within the historical geographic range of Santa Ana sucker that experiences peaks and ebbs in the water volume (either naturally or regulated) that encompasses areas that provide or contain sources of water and coarse sediment necessary to maintain all life stages of the species, including adults, juveniles, larva, and eggs, in the riverine environment.

(2) Stream channel substrate consisting of a mosaic of loose sand, gravel, cobble, and boulder substrates in a series of riffles, runs, pools, and shallow sandy stream margins necessary to maintain various life stages of the species, including adults, juveniles, larva, and eggs, in the

riverine environment.

(3) Water depths greater than 1.2 in (3 cm) and bottom water velocities greater than 0.01 ft per second (0.03 m per second).

(4) Clear or only occasionally turbid water.

(5) Water temperatures less than 86 °F (30 °C).

(6) In-stream habitat that includes food sources (such as zooplankton, phytoplankton, and aquatic invertebrates), and associated vegetation such as aquatic emergent vegetation and adjacent riparian vegetation to provide: (a) Shading to reduce water temperature when ambient temperatures are high, (b) shelter during periods of high water velocity, and (c) protective cover from predators.

(7) Areas within perennial stream courses that may be periodically dewatered, but that serve as connective corridors between occupied or seasonally occupied habitat and through which the species may move when the habitat is wetted.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain the physical and biological features that are essential to the conservation of the species and may require special management considerations or protection. All areas included in this final critical habitat designation will require some level of management to address the current and future threats to the physical and biological features essential to the conservation of Santa Ana sucker. Special management considerations or protection may be required to minimize habitat destruction, degradation, and fragmentation associated with the following threats, among others: Water diversion; alteration of stream channels and watersheds; reduction of water quantity associated with urban development and human recreational activities, including swimming, and construction and operation of golf courses; and OHV use. For discussion of the threats to Santa Ana sucker and its habitat, please see the Summary of Comments and Recommendations and Summary of Factors Affecting the Species sections of the final listing rule (65 FR 19686; April 12, 2000) and the Public Comments and Critical Habitat Unit Descriptions sections of the 2005 final critical habitat rule (70 FR 425; January 4, 2005). Please also see Critical Habitat Units section below for a discussion of the threats in each critical habitat unit. In addition to the threats to Santa Ana sucker and its habitat described in the final listing and previous critical habitat rules, the physical and biological features essential to the conservation of Santa Ana sucker may require special management considerations or protection to minimize habitat destruction, degradation, and fragmentation associated with the construction of dams, the operation of recreational residences, the construction of road crossings and bridges across waterways, nonnative vegetation and predators, the impacts of wildfires to riparian and instream conditions, and the degradation of water quality. Recreational Dams Artificial manmade dams are often constructed from boulders, logs, and trash to create pools within these rivers for fishing, swimming, wading, and bathing (Ally 2003, p. 1; Chambers Group 2004, p. 6–4). The construction of these ‘‘recreational’’ dams degrades instream and possibly bank habitat, increases turbidity (PCE 4), disrupts sediment transport, and impedes upstream movement of Santa Ana suckers, especially during droughts (Ally 2003, pp. 1–3), thereby fragmenting habitat connectivity within occupied habitat. During the spawning season, these dams cause instream disruptions that can bury gravel beds (PCE 2) used for spawning (Ally 2003, p. 1). Recreational dams can also further degrade habitat by slowing water velocities (PCE 3), increasing water temperatures (PCE 5), and encouraging excessive growth of algae (Ally 2003, p. 3). In addition, presumably, because water depths increase and velocities decrease, these areas may harbor nonnative predators. Management activities that could ameliorate these threats include patrolling by enforcement officers or rangers throughout the accessible recreational areas within the critical habitat designation. Prevention of recreational dams will help protect the PCEs by ensuring the hydrologic system continues to function (PCE 1) by delivering cool, clear water with sufficient food sources (PCEs 2 through 6) that are essential to the conservation of Santa Ana sucker. Recreational Residences The U.S. Forest Service (USFS) issues special use permits for the operation and maintenance of private recreational residences within the boundaries of the Angeles National Forest along Big Tujunga Creek and the North and West Forks of the San Gabriel River. Improperly functioning septic systems at these residences can degrade water quality conditions by increasing water turbidity (PCE 4) as a result of the increased nutrient loads in the water (USFS 2007, p. 18), which lead to excessive algal growth. Management activities that could ameliorate these threats include limiting the number of allowable recreational residences and requiring that septic systems are properly functioning within areas that are hydrologically connected to areas designated as critical habitat. Limiting the number of residences and ensuring the proper function of their septic systems will help protect PCE 4 by preventing additional nutrient loads from entering the water and increasing water turbidity (PCE 4) to the detriment of Santa Ana sucker. Road Crossings and Bridges Road crossings and bridges constructed across waterways can impact Santa Ana sucker by creating permanent or intermittent barriers to upstream movement and fragmenting connective corridors between areas of occupied habitat (PCE 7). Bridge footings and pier protections (such as concrete aprons that span the waterway) accelerate water velocities (PCE 3) and, in the absence of sediment in the water (PCE 2), scour sediments from the streambed immediately downstream. With sufficient scouring, the elevation of the downstream bed of the stream may become so low that Santa Ana suckers cannot swim upstream from that point; scouring can also create pools that favor predatory nonnative fish. Culverts constructed under road crossings can act as barriers to movement when a culvert becomes filled in with sediment, reducing the amount of water (PCE 1) and sediment (PCE 2) that could be transported downstream. Drop structures that function as a support for road crossings or bridges as a result of gradient changes within the river may also create a temporary barrier to water and sediment transport and Santa Ana sucker movement. The extent, however, to which these structures constitute barriers depends on the quantity of water flowing and sediment transport in a given year and over time. For example, sediment-filled culverts that create a barrier to movement one year may be passable in another year if high water flows remove trapped sediments. Road crossings and bridges can also impact the species by altering the hydrology of the system (PCE 1), rerouting water flow into less suitable habitat. Management activities that could ameliorate these threats include modifying culverts or drop structures to ensure the connective corridor is maintained through a gradient that is passable by water and sediment and Santa Ana suckers (i.e., 7 degrees as described in the Criteria Used To Identify Critical Habitat section) within the critical habitat designation. Maintenance of these corridors (PCE 7) and ensuring a passable gradient (PCE 1) will help protect the PCEs (2 through 5) that are essential to the conservation of Santa Ana sucker. Water and Sediment Transport or Removal The transport of both water and sediment are essential components to the conservation of Santa Ana sucker (PCEs 1 through 5). The presence of sufficient water and appropriate sediment may be impacted by operations attributed, but not limited to, dams operation of hydroelectric power facilities, water diversion, sediment removal, or flood control activities. Natural flow regimes have inevitably been impacted in the Santa Ana River, Los Angeles River, and San Gabriel River basins as a result of alterations such as dams, diversions, channelization, or other flood control activities. The impacts to Santa Ana sucker and its habitat attributable to these activities have yet to be fully described or understood. However, as these activities continue, there appear to be impacts to Santa Ana sucker and its habitat through alteration of the hydrologic system and the function of the watershed as a whole. Recent research indicates that the presence of preferred substrates such as gravel and cobble in the Santa Ana River are less common at sites farther downstream compared to sites that are closer the Seven Oaks Dam (Thompson et al. 2010, p. 328). This is likely due to the presence of flowing water from the Rialto/RIX sewage treatment plant immediately upstream that clears out silt and fine sand and exposes gravel and cobbles; however, the flow diminishes downstream due to percolation. Therefore, in the occupied areas of the Santa Ana River, downstream areas contain less suitable habitat for Santa Ana sucker (Thompson et al. 2010, pp. 327–328). The extant populations of Santa Ana suckers throughout the species’ range are currently isolated from one another as a result of water diversions or dams that have likely resulted in their exclusion from suitable spawning and rearing habitat (Service 2000, p. 19693). Management activities that could ameliorate these threats throughout the species’ range include removing or preventing channelization and restoring the river with its natural substrates and riparian vegetation, increasing flows into occupied areas by decreasing the amount of water contained by dams or removed from the hydrologic system, preventing mining activities that remove coarse sediments, and preventing further instream modifications from flood control activities throughout the critical habitat designation. Maintenance of the natural flow (PCEs 3, 4, and 5) and sediment transport (PCE 2) will help protect the PCEs that are essential to the conservation of Santa Ana sucker. Off-Highway or Off-Road Vehicles (OHVs) Throughout the designated critical habitat, OHV use occurs in authorized and unauthorized areas. We are aware of authorized OHV activity in the USFS’s San Gabriel Canyon OHV Area at the junction of the East, North, and West Forks of the San Gabriel River. There have been reports of unauthorized OHV activity in the Santa Ana River, although the level of impact and frequency of use have not been quantified. However, the reach where the unauthorized OHV activities have been reported occurs just upstream of one of the remaining Santa Ana sucker populations (near Rialto/RIX; SAWPA 2010, p. 1–10). This area has recently been cleared of the nonnative plant, Arundo donax, which may have facilitated access for OHVs. The use of the river as an OHV recreational area may result in adverse effects to Santa Ana sucker by increasing turbidity (PCE 4); disrupting the physical structure of habitat for spawning, resting, and feeding (PCE 2); and introducing pollutants (such as oil and gas) into streams (PCE 4) (65 FR 19686; April 12, 2000). Management activities that could ameliorate these threats include patrolling by enforcement officers or rangers throughout the accessible recreational areas, providing signage to discourage access, or installing fencing where access is unauthorized within the critical habitat designation. Minimizing the impacts to the hydrologic system (PCE 1) and reducing the instream impacts (i.e., increased turbidity (PCEs 2 and 4)) and impacts to instream and riparian vegetation (PCE 6) attributed to OHVs will help protect the PCEs that are essential to the conservation of Santa Ana sucker. Nonnative Vegetation and Nonnative Predators The presence of nonnative vegetation (such as Arundo donax) may alter the hydrology and provide habitat conditions preferred by nonnative predators (such as largemouth bass and green sunfish) in the Santa Ana River and Big Tujunga Creek, and possibly (but to a lesser degree) in the San Gabriel River. These impacts may include (but not be limited to) decreased flow rates (PCE 3), increased turbidity (PCE 4), increased presence of pools and lack of preferred habitat (PCE 2), and increased abundance of nonnative predators (Service unpublished information 2010b, pp. 24–25). However, these types of impacts would need to be evaluated within the context of potential threats to the Santa Ana sucker. If this potential threat is found to impact the species, management activities to ameliorate this threat could include removal of nonnative vegetation and predators. Post-Wildfire Management The Station Fire of 2009 (described in more detail in Critical Habitat Units— Unit 3: Big Tujunga and Haines Creeks section below) may have long-lasting impacts to the Big Tujunga and Haines Creeks. These impacts may include (but not be limited to) increased debris-flow and flow velocity (PCEs 3 and 6) due to the lack of vegetation and increased runoff, increased turbidity (PCE 4) from the residual ash in the area and increased flow speeds, and possible residual contaminants entering the system as a result of the firefighting retardant chemicals which can alter water chemistry. The loss of riparian vegetation is likely to increase water temperature in the river due to the lack of shading available to instream habitats (USFS 2009, pp. 5–6). Management activities that could ameliorate these threats include revegetation of upland and riparian areas to stabilize hillsides and riparian zones to prevent erosion, and removal of large debris within the critical habitat designation before winter rains commence. Revegetation of upland and riparian areas will decrease debris flow and stabilize soils (PCEs 2, 4, and 6), which will help protect the PCEs that are essential to the conservation of Santa Ana sucker. Water Quality Degradation Although specific water quality tolerances have not been evaluated for Santa Ana sucker, elevated water temperature, diminished dissolved, oxygen, elevated turbidity, elevated specific conductance, and presence of certain chemicals (such as pharmaceuticals or endocrine disrupting compounds) from treated wastewater may impact Santa Ana sucker. These impacts may affect the physical and biological features essential to the conservation of the Santa Ana sucker and may include (but not be limited to) increased water temperatures (PCE 5), increased turbidity (PCE 4), and changes in instream food sources (PCE 6) that may have long-lasting effects on individual and population growth (reproductive success) and other normal behaviors. Management activities that could ameliorate these threats include identification of thresholds and tolerance levels specifically for Santa Ana sucker, implementation of water quality standards or regulations throughout its range, and minimization of discharges of harmful chemicals into the watersheds. Water quality regulations that address Santa Ana sucker's water quality requirements (PCEs 4, 5, and 6) will help protect the PCEs that are essential to the conservation of Santa Ana sucker.

Life History

Feeding Narrative

Adult: Santa Ana suckers are specialized invertivores and herbivores that feed principally on algae, diatoms, detritus, and small invertebrates. Adult suckers also eat the occasional insect larva. As they grow in size, aquatic insects make up a greater proportion of their diet. The species has widely distributed food resources. Competition potentially exists with nonnative species; however, further research is needed. Males and females appear to grow at an equivalent rate. The species is dependent on the availability of algae, diatoms, and detritus, as well as aquatic insects at the adult life stage. Resources required for feeding are stream systems that contain the appropriate quantity of coarse substrates, with some larger cobbles or boulders for growth of algae (NatureServe 2015, USFWS 2011, USFWS 2014).

Reproduction Narrative

Adult: Santa Ana suckers reproduce through oviparity, and females broadcast spawn. Santa Ana suckers in the Santa Clara River generally mature during their second summer, and typically have one reproductive event per year. Particularly at the beginning of the breeding season, spawning tubercles (raised growths on sexually mature fish) are present on most parts of the body of breeding males, and are heaviest on the anal fin, caudal fin, and lower half of the caudal peduncle (narrow region of body immediately in front of the caudal fin). Female suckers grow tubercles on the caudal fin and caudal peduncle. Spawning occurs between mid-March and early July, with peak activity usually in April.Females lay between 4,400 and 16,000 eggs per clutch, and leave their young to fend for themselves. The species exhibits high fecundity, (number of eggs or offspring produced), increasing linearly with body weight. Spawning takes place over gravelly riffles, where fertilized eggs adhere to the substrate and hatch within 360 hours. Larvae measure approximately 7 mm (0.28 in.) at hatching. Gravid female Santa Ana suckers are not smaller than 49 mm (1.9 in) or 2.05 grams (0.07 ounce). Santa Ana suckers in the Santa Clara River generally mature during their second summer and die at the end of their third summer at 75 to 110 mm (3 to 4.3 in.) standard length. However, some individuals have been observed to survive through a fourth summer growing to a size of 141 to 153 mm (5.6 to 6.0 in.) standard length, and those in the San Gabriel River may survive into their fifth summer. Maximum age appears to vary among the watersheds. The reasons for this are unknown, but it may possibly be due to the suitability of habitat and overall fish condition.

Geographic or Habitat Restraints or Barriers

Adult: Dams, water diversions, food control channels. The species does not occur above areas where the in-stream slope exceeds 7 degrees (USFWS 2014).

Spatial Arrangements of the Population

Adult: Uniform

Environmental Specificity

Adult: Narrow/specialist.

Tolerance Ranges/Thresholds

Adult: High

Site Fidelity

Adult: High

Habitat Narrative

Adult: Santa Ana suckers inhabit clear, cool rocky pools and runs of perennial streams, mountain streams, and rivers in alluvial floodplains with in-stream or bank-side riparian vegetation which contain algae. The species requires the presence of coarse substrates, including gravel, cobble, or a mixture of gravel or cobble with sand, and a combination of shallow riffle areas and deeper runs and pools, as well as vegetation to provide shade and cover for larvae and juveniles. Typically, this species is found in shallow streams less than 7 meters (22 feet) wide. Geographically, Santa Ana suckers do not occur above areas where the in-stream slope exceeds 7 degrees, and hydrological barriers affect the species dispersal and fragment the habitat. The species is uniformly arranged spatially in suitable habitat (NatureServe 2015; USFWS 2014).Individuals require periodic high-flow events (flood flows); juveniles require open sandy bars and adults require deep undercut banks and pools. The species is most abundant in clear water at temperatures that are typically less than 22 degrees °C (72 degrees °F). Tributaries may provide shallow-water refuge for juveniles from larger predatory fish, and may similarly act as refuge for juvenile and adult Santa Ana suckers during storm flows (NatureServe 2015; USFWS 2014).

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: Seasonal movements/migrations to spawning habitats.

Dispersal

Adult: Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats (NatureServe 2015).

Immigration/Emigration

Adult: No

Dispersal/Migration Narrative

Adult: Santa Ana suckers exhibit moderate mobility, and are a seasonally migratory species. Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats. Individuals do not immigrate nor emigrate between populations. The species requires streams that do not contain instream barriers, such as dams and culverts for dispersal. Generally, the species does not inhabit or disperse into reservoirs, preferring permanent streams with pools and riparian vegetation that provide cover and refuge from floods (USFWS 2014; NatureServe 2015).

Additional Life History Information

Adult: Generally, the species does not inhabit or disperse into reservoirs, preferring permanent streams with pools and riparian vegetation that provide cover and refuge from floods (NatureServe 2015).

Population Information and Trends

Population Trends:

Long-term trend: Decline of 70 to 80 percent (NatureServe 2015). Approximately 80 percent of the Santa Ana sucker's historical range has been lost in the Los Angeles River watershed, 75 percent in the San Gabriel River watershed, and 70 percent in the Santa Ana River watershed (USFWS 2014).

Species Trends:

Short-term trend: Decline of 10 to 50 percent (NatureServe 2015).

Population Growth Rate:

Survey data indicate that fish density is likely decreasing in areas in the Santa Ana River, and tends to be variable in Big Tujunga Creek and San Gabriel River (USFWS 2014).

Number of Populations:

6 (USFWS, 2023)

Population Size:

1,000 to 10,000 individuals; the total adult population size is unknown, but likely is not more than several thousand (NatureServe 2015).

Adaptability:

Low

Additional Population-level Information:

The abundance of Santa Ana suckers has been reduced in all three watersheds, because of the decrease in available habitat relative to the historical range of the species (USFWS 2014).

Population Narrative:

There are six populations in the following locations: (1) lower and middle Santa Ana River in San Bernardino, Riverside, and Orange counties; (2) lower Big Tujunga Creek in the Los Angeles River drainage in Los Angeles County; and (3) the east, west, and north forks of the San Gabriel River and San Dimas Wash in Los Angeles County. Approximately 80 percent of the Santa Ana sucker's historical range has been lost in the Los Angeles River watershed, 75 percent in the San Gabriel River watershed, and 70 percent in the Santa Ana River watershed. The current population is estimated to be between 1,000 and 10,000 individuals; the total adult population size is unknown, but likely is not more than several thousand. Survey data indicate that fish density is likely decreasing in areas in the Santa Ana River, and tends to be variable in Big Tujunga Creek and San Gabriel River. The abundance of Santa Ana suckers has been reduced in all three watersheds, because of the decrease in available habitat relative to the historical range of the species (USFWS 2014; NatureServe 2015).Yearly monitoring has occurred since 2001 in the Santa Ana River (near the junction of the Santa Ana River with California Highway 60 and upstream to Riverside Avenue). Over this 10-year survey period, results indicate a decline in the annual average estimate of Santa Ana suckers. The density of Santa Ana suckers in Big Tujunga Creek on the Los Angeles River is often low, likely due to the variability in habitat suitability. Santa Ana suckers are more abundant and in better condition (length-weight relationship) in the San Gabriel River, compared to those in the Santa Ana River (NatureServe 2015; USFWS 2014). Based on the information received, we updated the Santa Ana sucker occurrence status in Table 1. In this review, we consider an occurrence to be extant if the species was observed within the last 10 years. We consider the occurrence is presumed extant if the species has not been observed in the last 10 years, but suitable habitat is present. We consider the occurrence is possibly extirpated if the species has not been observed for over 10 years and the habitat is small, degraded, or separated by a permanent barrier. We consider the occurrence to be extirpated if the species has not been observed for greater than 20 years and the habitat is no longer suitable. Of the nine historical occurrences identified, six were considered extant in the 2011 5-year review among the three occupied watersheds. We now consider San Dimas Wash and the Lower Santa Ana River and Tributaries as possibly extirpated due to the lack of positive occurrences since 2013 (Chambers Group 2013, p. 6) and 2010 (RCRCD 2010, p. 4), respectively. San Dimas Creek was surveyed in 2014, and no Santa Ana suckers were positively identified. Negative survey data was reported in all subsequent surveys including 2011, 2014 (Aspen 2014, p. 2), late 2014 (Aspen 2014, p. 2), and 2018 (Aspen 2018, p. 4) on the lower Santa Ana River, after the last positive in 2010. Based on these updates, currently four occurrences are extant for this status review (USFWS, 2023).

Threats and Stressors

Stressor: Hydrological modifications
Exposure: Construction of water infrastructure.
Response: Habitat alteration.
Consequence: Loss of habitat/habitat degradation.
Narrative: Human activities, such as construction of dams, water diversions, flood control channels, roads, and other impervious surfaces, have altered the hydrology of the watersheds throughout Santa Ana sucker's range. These activities have impacted dispersal and modified habitat in such a way that much of it is no longer suitable. The Santa Ana sucker remains in a very small portion of its historical range, and although no additional construction of barriers to dispersal or further fragmentation of Santa Ana sucker habitat has occurred since its listing, habitat degradation continues due to ongoing operations of flood control and water conservation facilities and permanent modifications to the watersheds (USFWS 2014). Hydrological modifications that limit the dispersal of Santa Ana suckers include flood control dams, drop structures, recreational dams, road crossings (e.g., culverts), and levees. Large dams, such as Prado Dam, severely limit connectivity between Santa Ana suckers, only allowing limited unidirectional migration downstream. Recreational dams, such as low-flow barriers constructed out of rocks, vegetation, or other debris to create pools for recreation, create barriers during low-flow conditions, but may be passable during higher-flow conditions. Culverts and other road crossings may prevent access into tributaries or limit connectivity in the main river channel. Levees can prevent access to portions of the floodplain that were historically occupied by the species (USFWS 2014).

Stressor: Water quality
Exposure: Increased inputs of regulated and unregulated contaminants.
Response: Elevated stress of the fish.
Consequence: Population decline.
Narrative: Wastewater-dominated rivers, like the Santa Ana River, are subject to increased inputs of regulated and unregulated contaminants, which degrade water quality and habitat suitability. Contaminants in water discharged from sewage treatment facilities may be amplified because of the limited availability of cleaner, natural water to flush out or dilute residual chemicals. Degraded water quality affects this species primarily in the Santa Ana River, but may occur in association with recreational use in the other watersheds. Other water quality impacts to Santa Ana suckers include (but are not limited to) elevated temperatures and changes in hydrological regime attributed to global climate change, low oxygen levels attributed to increased nutrients causing algal blooms, and increased ammonia levels that are toxic to fish. Each of these scenarios may result in degradation of water quality in occupied habitat, elevated stress of the fish, lower reproductive input, or death (USFWS 2014).

Stressor: Nonnative vegetation
Exposure: Giant reed (Arundo donax) and filamentous red alga (Compsopogon coeruleus).
Response: Alteration of habitat, increased nonnative predation, and loss of spawning habitat.
Consequence: Population decline.
Narrative: Aquatic habitat may be modified by the presence of nonnative vegetation in a variety of ways. Giant reed (Arundo donax) is a nonnative, aquatic, perennial reed-like grass (Poaceae). It is commonly found growing along lakes, streams, and other wetted areas, but once established it can survive long periods of drought. Compared to other riparian vegetation, it is known to use

excessive amounts of water to supply exceptionally high growth rates. This species is considered a primary threat to riparian corridors because of its ease of establishment and ability to alter the hydrology of the system. Giant reed tends to form large, continuous, clonal rhizome masses that stabilize river or stream banks, altering the flow regime of the system, and preventing natural dynamic processes such as stream meandering, and deposition and scouring of sediments. The modification of in-stream habitat by giant reed can also reduce the suitability of habitat for Santa Ana sucker, and increase the potential to support nonnative aquatic predators (USFWS 2014). A nonnative, invasive, filamentous red alga (Compsopogon coeruleus) was recently identified in the Santa Ana River in 2014. This red alga has likely been introduced into the Santa Ana River multiple times. The first record for this species in the Santa Ana River was from 2012, where it was found near Yorba Linda Boulevard, Yorba Linda, California. The second and most recent observation in the Santa Ana River was made in February 2014, when it was found in the discharge pool of the Rapid Infiltration and Extraction Facility (RIX) in the City of Colton, California. The RIX discharge pool appears to be an introduction location, because the alga has not been found to occur upstream from this location. It attaches to hard substrates and exists as an aquatic epilith (growing on rocks) or epiphyte (growing on plants). In the upper Santa Ana River, the red alga was more abundant in areas composed of cobble or gravel substrate, and less abundant in areas dominated by sand (USFWS 2014).

Stressor: Wildfire
Exposure: Impact riparian vegetation.
Response: Alteration of habitat; increased predation.
Consequence: Population decline.
Narrative: Wildfire may impact riparian vegetation throughout occupied and unoccupied reaches of all three watersheds by eliminating vegetation that shades the water and moderates water temperature, or by producing silt-and-ash-laden runoff that can significantly increase turbidity of rivers. The loss of riparian vegetation may impact water transport, sediment transport, water quality, and flow regime. Large wildfires may threaten aquatic species by isolating populations and causing local extirpations. Wildfire has the potential to impact the Santa Ana sucker throughout its range, but impacts are expected to be localized and temporary. Therefore, we do not consider wildfire to be a substantial threat at this time (USFWS 2014).

Stressor: Vehicles
Exposure: Off-highway vehicles (OHV).
Response: Degradation of habitat.
Consequence: Habitat loss.
Narrative: OHVs impact both riparian and in-stream habitat that is important for Santa Ana suckers. Users of OHVs may drive along the banks of rivers, which can degrade bank stability and lead to erosion, and damage riparian plant communities that provide shade over the river and increase bank stability. OHVs may also drive through the river and disturb sediments, create increased turbidity, potentially crush Santa Ana suckers, and otherwise disturb substrates that Santa Ana suckers require for feeding and rearing young. OHV use primarily occurs in the San Gabriel Canyon OHV area, at the confluence of the east and west forks of the San Gabriel River and above Mission Avenue, in the Santa Ana River. The San Gabriel Canyon OHV area is currently being managed by the U.S. Forest Service (USFS) to reduce impacts to the species, and is monitored to determine the effectiveness of management actions (e.g., Ecorp Consulting). OHV use in the Santa Ana River is unauthorized. Although OHV use is currently not considered a substantial threat, it has the potential to significantly impact Santa Ana sucker in the absence of

specific management actions and enforcement (USFWS 2014).

Stressor: Mining activities
Exposure: In-stream mining.
Response: Alteration/degradation of habitat.
Consequence: Habitat loss.
Narrative: Sand and gravel are used as construction aggregate for public works projects such as roads and highways, and a multitude of other commercial uses. In-stream mining alters the channel geomorphology and bed elevation, and can require water diversion, clearing, and excavation. The practice of in-stream mining may induce channel incision and erosion, but more importantly for Santa Ana suckers, mining for gravel and sand removes necessary substrates from the watershed and discharges fine residual sediment back into the watershed. These activities have occurred in the Santa Ana River upstream of occupied habitat areas. Additionally, suction dredging to find precious minerals is generally a recreational activity that occurs most frequently on USFS lands. These activities have been known to occur in the San Gabriel River and Los Angeles River watersheds; however, as of August 6, 2009, the California Department of Fish and Wildlife imposed a moratorium on in-stream suction dredging until the State of California completes a court-ordered environmental review, and adopts a permitting program. Sluicing and high banking, techniques also used to find precious minerals, are likely occurring in the San Gabriel River and to a lesser extent in Big Tujunga Creek. Although mining is not currently considered a substantial threat, changes in restrictions that increase the range-wide extend of mining activities could have a substantial impact on the species (USFWS 2014).

Stressor: Predation
Exposure: Nonnative predators.
Response: Individuals removed from population.
Consequence: Unknown
Narrative: Nonnative predators such as bass and sunfish (Family Centrarchidae), tilapia (Family Cichlidae), carp (Family Cyprinidae), and catfish (Family Ictaluridae) have been reported in each of the watersheds currently occupied by Santa Ana sucker. The American bullfrog (Rana catesbeiana), another potential predator, has also been observed in Big Tujunga (Haines Creek) and the Santa Ana River near the confluence with Rialto Channel. The relative abundance of Santa Ana suckers appears to decrease with increasing numbers of exotic fish. An increase of nonnative predators would suggest increased predation pressures, which could further impact Santa Ana sucker; however, further study is needed to determine the quantity of Santa Ana suckers consumed by nonnative predators to better describe the magnitude of this threat (USFWS 2014).

Stressor: Regulatory mechanisms
Exposure: Inadequacy of existing regulatory mechanisms.
Response: Loss of habitat or habitat degradation from populations, and potential improper identification and maintenance of populations.
Consequence: Reduction in population, extirpation, and habitat loss and degradation.
Narrative: In the listing rule, regulatory mechanisms thought to have some potential to protect Santa Ana sucker included: (1) the California Endangered Species Act (where the Santa Ana sucker occurred in areas where state-listed species are located); (2) the California Environmental Quality Act; (3) the National Environmental Policy Act; (4) the Clean Water Act; (5) the federal Endangered Species Act (ESA) (where, prior to listing, Santa Ana sucker co-occurred with other

federally listed species); and (6) land management or conservation measures by federal, state, or local agencies or by private groups and organizations. The listing rule provides an analysis of the potential level of protection provided by these regulatory mechanisms. Other federal and state regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under ESA. No new regulatory mechanisms that have been enacted since the time of listing that would preclude the need for protection of the species under ESA. Therefore, in the absence of ESA, other laws and regulations have limited ability to protect the species (USFWS 2014).

Stressor: Small population
Exposure: Loss of historical range, and reduced abundance.
Response: Vulnerability to extirpation during stochastic events.
Consequence: Population decline/extirpation.
Narrative: The majority of the Santa Ana sucker's historical range was lost prior to listing, and the distribution of this species has continued to constrict in portions of the San Gabriel River and Santa Ana River watersheds. Small population size may be the result of several conditions, including the species' inability to recolonize previously occupied areas and the lack of redundant tributaries or refuge habitat to prevent extirpation due to catastrophic events. Survey data indicate that fish density is likely decreasing in areas in the Santa Ana River, and tends to be variable in Big Tujunga Creek and San Gabriel River. Small populations of Santa Ana sucker are more vulnerable to extirpation during stochastic events, such as flood, fire, or sustained drought. Given the impact these events could have on any of the three watersheds where Santa Ana suckers exist, they represent a potential threat to the species as a whole (USFWS 2014).

Stressor: Climate change
Exposure: Global and regional changes in climate.
Response: Loss of individuals and continued reduction in population.
Consequence: Reduction and/or loss of habitat, reduction in population, and population extirpation.
Narrative: Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate that warmer air temperatures, more intense precipitation events, and increased summer continental drying are predicted by the year 2100. Although Santa Ana suckers are capable of withstanding elevated water temperatures, their lethal upper temperature limit is unknown. Fish are generally more stressed at the upper extremes of their temperature range, and though they may be able to survive, elevated temperature is an example of a stressor that may affect them through decreased growth and reduced disease resistance. All life stages of Santa Ana suckers require cool water. However, connectivity in the watersheds may be exacerbated by the predicted decreases in annual precipitation, and fish may not have access to areas with cool, clean water because of the lack of water or barriers to dispersal. Increasing air temperatures and decreasing precipitation levels, predicted to occur as a result of global climate change, are likely to impact the availability of suitable cooler-water habitat. Therefore, though difficult to quantify, change in global climate may impact the Santa Ana sucker throughout its range (USFWS 2014).

Recovery

Reclassification Criteria:
There are currently no criteria for reclassification or uplisting for the Santa Ana sucker.

Recovery Priority Number: 6C

Delisting Criteria:
Adequate amounts of suitable habitat are restored, protected, and managed in each recovery unit to support viable populations of all life stages of Santa Ana sucker and provide resiliency and redundancy to protect against catastrophic events throughout the current range of the species (USFWS 2014).

Management is implemented to reduce competition and predation by nonnative species to levels determined to be necessary for the maintenance of viable Santa Ana sucker populations (USFWS 2014).

The current range of the species is expanded through modification or removal of existing barriers, restoration of suitable habitat, and/or reintroduction of the species to areas within its historical range, in a configuration that ensures with reasonable certainty that the remaining genetic makeup of the species has been preserved and can withstand catastrophic events in the watershed (USFWS 2014).

Appropriate gene flow is maintained between occupied areas of each Regional Unit, through natural processes or management, to ensure population viability and genetic exchange (USFWS 2014).

Stable or increasing population averaged over 15 years in the Santa Ana River, Los Angeles River, and San Gabriel River Recovery Units, and occupancy in each of the following areas:. Santa Ana River Watershed Recovery Unit – –Santa Ana River in the Prado Reach and Imperial Reach; –Four tributaries in the Prado Reach and/or Imperial Reach (for example Tequesquite Arroyo, Anza Drain, Hole Creek, Evans Drain, Sunnyslope Creek, Day Creek, Aliso Creek); and –Three tributaries in the La Cadena Reach (for example City Creek, Lytle Creek, Cajon Wash, Alder Creek, Plunge Creek, Santa Ana River above Seven Oaks Dam). Los Angeles River Watershed Recovery Unit – – Big Tujunga Creek in the Hansen Reach; – Two tributaries in the Hansen Reach (for example, Haines Creek, Little Tujunga Creek); and – One tributary in either the Big Tujunga Reach or Los Angeles Reach (for example, Fall Creek, Mill Creek, Arroyo Seco Creek). San Gabriel River Watershed Recovery Unit – – The east, west, and north forks of San Gabriel River in the San Gabriel Reach; – Three tributaries in the San Gabriel Reach (for example, Bear Creek, Big Mermaids Creek, Cattle Canyon Creek); and – Either the Cogswell Reach, the East Fork above the "Bridge to Nowhere", or one tributary in the Whittier Reach (for example, San Dimas Wash, Fish Canyon Creek) (USFWS 2014).

A long-term monitoring and management plan is in place to evaluate the effectiveness of management actions to address ongoing threats, and to identify new threats that may require implementation of adaptive management actions (USFWS 2014).

Recovery Actions:
- Develop and implement a range-wide monitoring protocol to accurately and consistently document populations, occupied habitat, and threats (USFWS 2014).
- Conduct research projects specifically designed to inform management actions and recovery (USFWS 2014).

- Increase the abundance and distribution of the Santa Ana sucker within its current range by reducing threats to the species and its habitat (USFWS 2014).
- Increase the range of the Santa Ana sucker by restoring habitat (as needed), and reestablishing occurrences within its historical range (USFWS 2014).
- Assess and evaluate water allocations range-wide to determine habitat limitations, and implement management actions to ensure that sufficient water is available (USFWS 2011).
- Assess and evaluate sediment transport range-wide to determine habitat limitations, and implement management actions to ensure suitable habitat (coarse substrate) is available (USFWS 2011).
- Conduct range-wide studies and implement a monitoring protocol leading to a better understanding of life history strategies, such as patterns of migration, reproduction, and recruitment (USFWS 2011).
- Evaluate the effects of nonnative predators and nonnative riparian vegetation that impact Santa Ana suckers, and initiate management actions to ameliorate potential impacts (USFWS 2011).
- Assess the sensitivity of the Santa Ana sucker relative to standard test organisms used to determine water quality standards. This may include investigation of impacts from chemicals such as compounds traditionally found in treated wastewater and unregulated "emerging" contaminants, including new generation pesticides, steroids and hormones, personal care products, prescription and nonprescription drugs, antibiotics, household disinfectants, insect repellants, and fire retardants (USFWS 2011).
- Determine whether genetic distinctness exists among the three watersheds where the listed entity occurs, and determine the status of the Santa Clara River occurrence (USFWS 2011).
- Work with partners, such as the U.S. Fish and Wildlife Service’s Partners for Fish and Wildlife Program, to identify opportunities for conservation or preservation of the Santa Ana sucker. Restore or maintain important tributaries or areas of the floodplain (i.e., abandoned golf courses) that have been disconnected from the mainstem (i.e., Sunnyslope Creek) or are currently urban outfalls that have been channelized (e.g., Day Creek and Evans Drain) (USFWS 2011).
- Implement management actions to minimize impacts from recreational activities associated with OHV use, rock dams, recreational residences, and recreational mining (or dredging) for precious metals (USFWS 2011).
- Assess areas outside the currently occupied range of the species but within the historical range that may serve as suitable reintroduction sites (USFWS 2011).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The recommended actions listed below are to be initiated over the next 5 years. The actions are intended to reduce threats to the Santa Ana sucker and provide information to better understand the biological and physical factors limiting the population growth and distribution. We recognize that conservation of this species will require cooperation and coordination with partners to minimize impacts from current threats, aid future restoration, and maximize effectiveness of limited funding. 1. Conduct a species status assessment to evaluate Santa Ana sucker viability in the four watersheds where the species occurs. 2. Continue to expand the current distribution of the Santa Ana sucker through augmentation or reintroduction efforts. a. Assess areas outside the currently occupied range of the species that may serve as suitable reintroduction sites. b. Conduct translocation activities upstream of Cogswell Dam and monitor efforts for the next 5 years. c. Conduct translocation activities upstream of Big Tujunga Dam and monitor efforts for the next 5 years. d. Prepare and implement restoration and reintroduction plan(s) for the Santa Ana River RU. e. Expand the captive rearing facilities in the Santa Ana River RU to facilitate translocations, if needed. f. Use the 10(j) designation to establish additional populations that contribute to species recovery. 3. Implement management actions to minimize impacts from recreational activities associated with OHV use, rock dams, recreational residences, and recreational mining (or dredging) for precious metals throughout range. 4. Manage predators in all RUs. 5. Utilize conservation easements on streams as a long-term management tool in lower tributaries. 6. Work with partners to identify opportunities for conservation or preservation of Santa Ana sucker occurrences on private lands. Support land acquisition to meet recovery goals. Work with local, State, and Federal partners to identify and leverage funding (i.e., section 6) to acquire habitat for the Santa Ana sucker (USFWS, 2023).

Additional Threshold Information:

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SPECIES ACCOUNT: *Catostomus warnerensis* (Warner sucker)

Species Taxonomic and Listing Information

Listing Status: Threatened (50 FR 39117); 09/27/1985; Region 8 - Nevada; Region 1 - Oregon (NatureServe 2015)

Physical Description

The Warner sucker is a slender-bodied fish, with a maximum length of 50.8 centimeters (cm) (20 inches [in.]). The top two-thirds of the head and body are blanketed with dark pigment, which borders creamy white lower sides and belly. During spawning season, males have a red lateral band along the midline of the body and females are lighter (USFWS 2013; USFWS 2014).

Taxonomy

The Warner sucker was first described in 1908 by Snyder and belongs to the Castomidae family. No taxonomic changes have occurred for the Warner sucker since its first description (ITIS 2015).

Historical Range

See current range/distribution.

Current Range

The Warner sucker is endemic to all streams and lakes of Warner basin in southeastern Oregon, extreme northeastern California, and extreme northwestern Nevada (USFWS 2014). The three main lakes where the Warner sucker is found are Hart Lake, Crump Lake, and Pelican Lake. Other lakes where the Warner sucker is found go as far north as Flagstaff Lake and "include[s] the Anderson, Swamp, Mugwump, Upper Campbell, Campbell, Stone Coral, and Bluejoint lakes; and all the sloughs and canals connecting these lakes; and three major stream basins that are tributaries to these lakes (Deep Creek, Twenty-mile Creek, and Honey Creek)" (IUCN 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/27/1985.

Legal Description

On September 27, 1985 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Catostomus warnerensis (Warner sucker) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes five critical habitat units (CHUs) in Oregon (50 FR 39117-39123).

The critical habitat designation for Catostomus warnerensis includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Catostomus warnerensis.

Critical Habitat Designation

The critical habitat designation for Catostomus warnerensis includes five CHUs (5 total subunits) in Lake County, Oregon (50 FR 39117-39123).

Twelvemile Creek-Approximately 4 stream miles and 50 feet on either side of the stream commencing at the confluence of Twelvemile Creek and Twentymile Creek and extending upstream, and including those portions of Twelvemile Creek in T4OS, R23E, Section 35: and T41S. R23E, Sections 1, 2.12, 13.23, and 24.

Twentymile Creek-Approximately 18 stream miles and 50 feet on either side of the stream commencing about 9 miles upstream of the junction of Twelvemile and Twentymile Creeks and extending to a point about 9 miles downstream of the junction, and including those portions of Twentymile Creek in TM.S, RZZE. Sections 25.35, and 38; T4OS R23E. Sections 19, 20, 24, 25, 28, 29, 30. 33,34,35 and 36; T4OS. R24E. Sections 15.18; 19, 20, 21, 22, 28, 29, 30; and T41S, R23E, Sections 2 and 3.

Spillway Canal north of Hart Lake-Approximately 2 stream miles and 60 feet on either side of the waterway commencing at its confluence with Hart Lake and extending to a point about 2 miles downstream, and including those portions of the waterway in T36S, R24E, Sections 7, 18. and 19.

Snyder Creek-Approximately 3 stream miles and 50 feet on either side of the stream commencing at the confluence of Snyder Creek and Honey Creek and extending to a point about 3 miles upstream on Snyder Creek, and including those portions of Snyder Creek in T39S. R22E, Sections 1 and 12: and T39S. R23E, Sections 7,17, and 19. 5

Honey Creek--Approximately 16 stream miles and 59 feet on either side of the stream commencing at the confluence of Honey Creek with Hart bake and extending to a point about 16 miles upstream on Honey Creek, and including those portions of Honey Creek in T39S. R24E. Sections 19, 2927.2J3, 29,30,33,34, and 35; T3BS. R23E, Sections 17, 19.20.2~ 22,23.24,29,27, and 28; and T38S. R22E. Section a 13,14.22, and 23.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (50 FR 39117-39123):

(1) Streams 15 feet to 60 feet wide with gravel-bottom shoal and riffle areas with intervening pools.

(2) Streams should have clean, unpolluted flowing water and a stable riparian zone.

(3) The streams should support a variety of aquatic insects. crustaceans, and other small invertebrates for food.

Special Management Considerations or Protections

The Secretary has discretion under section 4(d) of the Act to issue such special regulations as are necessary and advisable for the conservation of a threatened species. The Warner sucker is threatened primarily by habitat disturbance or alterations, not by intentional, direct taking of the species or by commercialization. Given this fact, and the fact that the State of Oregon regulates direct taking of the species through the requirement of State collecting permits, the Service has concluded that the State's collection permit system is adequate to protect the species from excessive taking, so long as such takes are limited to: educational purposes, scientific purposes, the enhancement of propagation or survival of the species, zoological exhibition, and other conservation purposes consistent with the Endangered Species Act. Therefore, the special rule adopted herein allows take of the Warner sucker for the above-stated purposes without the need for a Federal permit if a State collection permit is obtained and all other State wildlife conservation laws and regulations are satisfied. Rules are also promulgated to allow incidental take of the species during recreational fishing activities if the fishing is conducted in accordance with State law and if the Warner suckers are returned immediately into their habitat. The Service acknowledges that incidental take of the species by State-licensed recreational fishermen is not a significant threat to the Warner sucker. It should be recognized that any activities involving the taking of this species not otherwise enumerated in the special rule are prohibited. Without this special rule, all of the-prohibitions under 50 CFR 17.31 would apply. The Service believes that this special rule will allow for more efficient management of this species, thereby facilitating its conservation. For these reasons, the Service has concluded that this regulatory action is necessary and advisable for the conservation of the Warner sucker.

Life History

Feeding Narrative

Juvenile: Larvae actively search for food at the surface of the stream or lake or in the mid-channel current during daylight. Larvae feed on floating and submerged invertebrates, mostly planktonic crustaceans. Larvae avoid the water surface and mid-channel current at night. The larvae are fast-growing (USFWS 1998; USFWS 2014).

Adult: Adult Warner suckers are opportunistic benthic feeders and graze on the bottoms of streams and lakes for diatoms, algae, and detritus. The food they eat is widely distributed; however, they are often in competition with nonnative invasive species (USFWS 2015).

Reproduction Narrative

Juvenile: Larvae hatch in streams and stay in spawning pools until they are 2 to 3 years old. Spawning pools are used as rearing habitat; yearlings are found at the bottom of pools, and juveniles find deep areas of the stream where they can reside protected from the main current (USFWS 2010). It is only when the Warner sucker is 2 or 3 years old that they migrate out of the spawning/rearing ground (USFWS 1998).

Adult: Adult Warner suckers are broadcast spawners that spawn from April to early June when the water warms. Warner suckers can breed starting at 3 to 4 years of age, and live to be up to 17. The Warner sucker has two life histories that have evolved in response to differences in environmental influences between the stream and lake residences. Lake-dwelling Warner suckers migrate to streams to breed unless low water levels have cut off access to streams. When water levels are low, lake and stream Warner suckers are cut off from each other and lake Warner suckers will attempt to spawn on shallow gravel beds of the lake. Stream-dwelling Warner suckers spawn on the edges of low-gradient streams (USFWS 2010).

Geographic or Habitat Restraints or Barriers

Juvenile: Drought and low water levels can cause areas to dry up and cut off access to and from streams, lakes, and spawning grounds (USFWS 1998).

Adult: Drought and low water levels can cause areas to dry up and cut off access from streams to lakes.

Spatial Arrangements of the Population

Juvenile: Clumped according to environmental conditions.

Adult: Clumped according to environmental conditions.

Environmental Specificity

Juvenile: Broad/generalist or community with all key requirements common.

Adult: Semi-generalist.

Site Fidelity

Juvenile: High

Adult: High

Habitat Narrative

Juvenile: Larvae occupy pools or stream margins where there is little to no current, and use aquatic plants for cover. Larvae stay in spawning grounds until they are 2 to 3 years old, when they travel out of their spawning grounds of origin. When water levels are low, Warner suckers can get stuck in the spawning grounds and are be unable to move to other areas (NatureServe 2015; USFWS 2010).

Adult: Adults Warner suckers live in slow-moving lakes, streams, and pools. In lakes, Warner suckers are generally found in the deepest available water (generally less than 3.4 meters [11.2 feet] deep), where food is plentiful. Lake-dwelling Warner suckers travel to streams for spawning. Warner suckers require clean, cool water, and need amounts of water adequate to allow travel from lakes into spawning areas. Warner suckers can live up to 17 years (USFWS 1998).

Dispersal/Migration

Motility/Mobility

Juvenile: High

Adult: High

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Local migrant. Nonmigratory until 2 to 3 years of age, when they leave the spawning grounds for the first time. Young Warner suckers travel out of spawning areas after 2 to 3 years of age (USFWS 2010).

Adult: Locally and seasonally migrates to spawning streams (NatureServe 2015).

Immigration/Emigration

Juvenile: Unlikely

Adult: Unlikely

Dispersal/Migration Narrative

Juvenile: Young Warner suckers do not migrate until they reach 2 to 3 years of age. Adequate water levels need to be present, so that channels from streams to lakes are not blocked and Warner suckers are able to travel out of spawning areas and to other habitats (USFWS 2010).

Adult: Adult Warner suckers migrate seasonally to reach breeding ponds. Adequate water levels need to be present, so that channels to spawning habitat are not blocked; drought can cut off access to spawning grounds (USFWS 2010).

Population Information and Trends

Population Trends:

Decreasing

Species Trends:

Decreasing

Number of Populations:

This species is represented by one metapopulation; the subpopulations fluctuate with water availability (USFWS 2014).

Population Size:

2,500 to 10,000 (NatureServe 2015). Estimates are at least several thousand for the total metapopulation (USFWS 1998; USFWS 2010).

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Moderate for native diseases. Low for diseases from invasive species such as the white crappie, black crappie, brown bullhead, and largemouth bass.

Adaptability:

Low

Population Narrative:

This species is represented by one metapopulation; the subpopulations fluctuate with water availability (USFWS 2014). The population size is not well known, but is estimated to be 2,500 to 10,000 individuals (NatureServe 2015; USFWS 2010). As a whole, the species population is in decline.

Threats and Stressors

Stressor: Habitat modification and destruction (irrigation diversion, watershed degradation)
Exposure: Direct; water levels go down, eliminating the chance for fish to spawn in streams. Direct; irrigation practices can pollute water.
Response: Reduced spawning. Warner suckers can die from polluted water.
Consequence: Reduction in population numbers, decreased reproductive success.
Narrative: The Warner sucker is endemic to the Warner valley in south-central Oregon. The species typically travels to streams to spawn. Instream barriers and diversion structures have prohibited the movement of suckers into spawning streams. Habitat modification to streams and lakes in the basin has been substantial due to farming activities. During low flows, water is diverted elsewhere, eliminating the chance for fish to spawn in streams. Sometimes streams are diverted into agricultural fields, where fish end up dying (50 FR 39117). Irrigation dams and canals block access to some spawning streams. Irrigation can also negatively affect streams through water pollution and siltation. Irrigation practices can cause sudden and drastic changes in water level in the lower reaches of the streams, thereby stranding fish in the streams, sloughs, and lakes at the time of low flow (USFWS 1998).

Stressor: Competition and predation by introduced exotic species.
Exposure: Direct; introduced species prey upon Warner suckers at all life stages. Indirect; introduced species out-compete Warner suckers for resources.
Response: Mortality, more vulnerable to predation.
Consequence: Reduction in population numbers, decreased reproductive success.
Narrative: Exotic fishes were introduced to the Warner Valley in the early 1970s for sport and recreation. Nonnative fish dramatically altered the lake environments. The introduction of exotic fish led to large reductions in the numbers of Warner suckers, which previously had more extensive availability of safe rearing habitat, even with degraded stream conditions and blockages of migration corridors. Exotic fishes threaten the Warner sucker by out-competing them for food and resources, and by preying on Warner suckers at all life stages (eggs, larval, juvenile, and adults). Nonnative species also introduce parasites and disease to which the Warner sucker is not used to (50 FR 39117). Introduced fish include white crappie, black crappie, brown bullhead, and largemouth bass. Introduction of these nonnative piscivorous fish is thought to have sharply curtailed the successful recruitment to lake populations of Warner sucker (USFWS 1998).

Stressor: Drought
Exposure: Direct; water levels are lower.
Response: Reduced spawning.
Consequence: Reduction in population numbers, decreased reproductive success.
Narrative: Any prolonged drought will hasten the demise of the Warner sucker if all or most of the water in the streams is diverted (50 FR 39117). Drought restricts movement and migration. Prolonged drought, particularly desiccation of lakes from drought and irrigation use, and the drying or reduced stream flow of stream channels from irrigation water removal, greatly impact the species' viability and recovery (USFWS 2010). In years with ample water runoff, the amount of water diverted from streams would be only a portion of the total flow; but in drought years, the total streamflow does not meet the demand for existing water rights, so the entire streamflow may be diverted by the irrigators (USFWS 1998). Over a series of droughts, reduced flows can cause the lake levels to drop, and in conjunction with pumping of water from the lake, result in completely drying the lakes. Natural decreases in water levels already reduce the

Warner sucker population during periods of drought, which are aggravated by irrigation demands for water (USFWS 1998).

Recovery

Reclassification Criteria:
None
None
None
None
None

Delisting Criteria:
A self-sustaining metapopulation (a group of populations of one species coexisting in time but not in space) is distributed throughout the Twenty-mile, Honey, and Deep Creek (below the falls) drainages; and in Pelican, Crump, and Hart lakes. Self-sustaining populations will be determined based on parameters such as multiple age-classes; stable or increasing population size; document reproduction and recruited and a self-sustaining population from a viable metapopulations large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes (USFWS 1998; USFWS 2010).

Passage is restored within and among the Twenty-mile, Honey, and Deep Creek (below the falls) drainages, so that the individual populations of Warner suckers can function as a metapopulation (USFWS 1998; USFWS 2010).

No threats exist that would likely threaten the survival of the species over a significant portion of its range (USFWS 1998; USFWS 2010).

None
None

Recovery Actions:
- Protect and rehabilitate fish populations and habitat (USFWS 1998; USFWS 2010).
- Conserve genetic diversity of fish populations (USFWS 1998; USFWS 2010).
- Ensure that adequate water supplies are available for listed fish recovery (USFWS 1998; USFWS 2010).
- Monitor fish populations and habitat conditions (USFWS 1998; USFWS 2010).
- Evaluate long-term effects of climate trends on the recovery of fisheries (USFWS 1998; USFWS 2010).
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Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS: 1 . The WBAHP should continue to implement a comprehensive, prioritized passage and screening strategy to benefit Warner sucker and redband trout in the Warner Valley. 2. Continue to work with private landowners to reduce migration risks to Warner sucker.. Seek opportunities to assist landowners in improving irrigation efficiencies to create more water availability for both landowners and fish. 3 . Continue ongoing and seek new

opportunities to recognize contributions and cooperation from the landowners and irrigators in completing important fish passage and screening projects. Fifteen years of collaborative efforts have led to increased cooperation of multiple landowners in the Warner Basin, and we are grateful for their sincere interest and support. These efforts are the most important factors contributing to the recovery of Warner sucker and it is essential we continue to work with and support the efforts of landowners whose livelihoods depend on water in the Warner Basin. 4. Review recovery progress leading to delisting ofthe species based on the completion of irrigation diversion improvements resulting in fish passage allowing Warner sucker free and un-obstructed up and down stream movement. Evaluate progress toward recovery based on compartmentalized progress. For example, once all the diversion structures are complete for fish passage in Twentymile Creek, threat factor two would be ameliorated within the Twentymile Creek portion ofWarner sucker habitat. 5. The WBAHP should continue to implement the SAP and monitoring plan for Warner sucker populations and the efficacy of passage and screening projects. Additionally, when feasible monitoring should seek to track fluctuations in fish abundance, quantity and quality of available habitat, and abundance and impacts of normative species. (USFWS, 2019)

- Research Needs from Warner Workshop: • Determine at what age and what time of year Warner sucker move from the stream environment into the lake environment. • Evaluate water conservation opportunities to improve and maintain instream flows for Warner Suckers and other native fish. • Evaluate the Warner sucker's use of lower Deep Creek and the canal north of Hart Lake. • Evaluate the importance of the lakes in maintaining connectivity between tributary populations. (USFWS, 2019)

Additional Threshold Information:

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SPECIES ACCOUNT: *Chasmistes brevirostris* (Shortnose Sucker)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; July 18, 1988 (53 FR 27130); Region 1 - Oregon, Region 8 - California (NatureServe 2015)

Physical Description

The shortnose sucker (Chasmistes brevirostris) grows to about 0.65 meter (m) (2.1 feet [ft.]) in length. It has a large head and thin, fleshy lips, the lower of which is deeply notched. They are dark on their back and sides and silvery or white on the belly (USFWS 2013b).

Taxonomy

This species is a members of a group of suckers (Family Catostomidae) which predominantly inhabit lake environments. Adults of this group, collectively known as “lake suckers,” typically are relatively large individuals. Lake suckers differ morphologically from other suckers in having terminal or sub-terminal mouths. These species also generally possess numerous branched gill rakers. Both mouth position and gill raker structure suggest these species are adapted for feeding in a more forward manner on prey such as zooplankton rather than consuming prey from the substrate. This genus includes three extant species of lake suckers in the western United States, with the other two being the cui-ui sucker (Chasmistes cujus) in Pyramid Lake, Nevada, and the June sucker (Chasmistes liorus) in Utah Lake, Utah. The shortnose sucker is generally distinguished by a smaller head than the Lost River sucker (Deltistes luxatus), and by an oblique terminal mouth and thin but fleshy lips. The lower lip is deeply notched, giving the appearance of two separate lobes. Coloration is very similar to the Lost River sucker, with dark back and sides and a silvery or white belly. They are generally smaller than Lost River suckers. A combined assessment of mitochondrial (mtDNA) and nuclear DNA found that shortnose suckers are genetically indistinct (mtDNA) from Klamath largescale suckers (Catostomus snyderi) across the very small fraction of the total genome that has been analyzed. Similarly, microsatellite markers indicate that shortnose suckers regularly interbreed with Klamath largescale suckers. However, despite the apparent high rates of introgression (movement of genes) between these two species, shortnose suckers maintain their morphological distinctiveness to a large extent, although intermediate hybrid forms do occur. Genetic variation of mtDNA among populations of shortnose suckers suggests that populations in the Lost River sub-basin and lower Klamath River reservoirs are somewhat genetically distinct from the Upper Klamath Lake populations (USFWS 2013a; USFWS 2013b).

Historical Range

Shortnose suckers are endemic to the upper Klamath River basin, including the Lost River and Lower Klamath Lake sub-basins in southern Oregon and northern California. It is difficult to know precisely which tributaries and bodies of water this species historically occupied because records are sparse, but shortnose suckers occurred in Upper Klamath Lake, Lower Klamath Lake, Tule Lake, and Clear Lake Reservoir as well as the major tributaries to these water bodies, including the Sprague River, Wood River, Lost River, Willow Creek, and the Klamath River above Lower Klamath Lake (USFWS 2013b).

Current Range

At the time of listing, shortnose suckers occurred in Upper Klamath Lake and its tributaries and in a “substantial” population in Copco Reservoir on the Klamath River (Klamath County, Oregon, and Siskiyou County, California, respectively). Populations in J.C. Boyle Reservoir, Lake of the Woods (both in Klamath County, Oregon), and Iron Gate Reservoir (Siskiyou County, California) were believed to be very small or extirpated. The population in Clear Lake Reservoir (Modoc County, California) was noted to be hybridized with Klamath largescale sucker in the listing rule. Additional evidence documenting the occurrence of shortnose suckers in Keno Reservoir (Lake Ewauna) along the Klamath River (Klamath County, Oregon), Tule Lake (Siskiyou County, California), and Gerber Reservoir (Klamath County, Oregon) has emerged since listing (USFWS 2013b).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 12/11/2012.

Legal Description

On December 11, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Chasmistes brevirostris (Shortnose sucker) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two critical habitat units (CHUs) in Oregon and California (77 FR 73740-73768).

Critical Habitat Designation

The critical habitat designation for Chasmistes brevirostris includes two CHUs in Klamath and Lake Counties, Oregon, and Modoc County, California (77 FR 73740-73768).

Unit 1: Upper Klamath Lake Unit, Klamath County, Oregon.

Unit 2: Lost River Basin Unit, Klamath County, Oregon.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Chasmistes brevirostris critical habitat consists of three components in Oregon and California (77 FR 73740-73768):

(i) Water. Areas with sufficient water quantity and depth within lakes, reservoirs, streams, marshes, springs, groundwater sources, and refugia habitats with minimal physical, biological, or chemical impediments to connectivity. Water must have varied depths to accommodate each life stage: Shallow water (up to 3.28 ft (1.0 m)) for juveniles, and deeper water (up to 14.8 ft (4.5 m)) for adults. The water quality characteristics should include water temperatures of less than 82.4 [deg]F (28.0 [deg]Celsius); pH less than 9.75; dissolved oxygen levels greater than 4.0 mg per L; low levels of microcystin; and un-ionized ammonia (less than 0.5 mg per L). Elements also include natural flow regimes that provide flows during the appropriate time of year or, if flows are controlled, minimal flow departure from a natural hydrograph.

(ii) Spawning and rearing habitat. Streams and shoreline springs with gravel and cobble substrate at depths typically less than 4.3 ft (1.3 m) with adequate stream velocity to allow spawning to occur. Areas containing emergent vegetation adjacent to open water provides habitat for rearing and facilitates growth and survival of suckers, as well as protection from predation and protection from currents and turbulence.

(iii) Food. Areas that contain an abundant forage base, including a broad array of chironomidae, crustacea, and other aquatic macroinvertebrates.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features that are essential to the conservation of the species and which may require special management considerations or protection. Threats identified in the final listing rule for these species include: (1) Poor water quality; (2) potential entrainment at water diversion structures; (3) lack of access to essential spawning habitat; (4) lack of connectivity to historical habitat (i.e., migratory impediments); (5) degradation of spawning, rearing, and adult habitat; and (6) avian predation and predation by or competition with nonnative fish. Poor water quality is particularly associated with high abundance of the blue-green alga Aphanizomenon flos-aque. Core samples of bottom sediments indicate that A. flos-aque was not present in Upper Klamath Lake prior to the 1900s (Bradbury et al. 2004, p. 162; Eilers et al. 2004, p. 14). Its appearance is believed to be associated with increases in productivity of the lake through human influence (NRC 2004, pp. 108-110). This alga now dominates the algal community from June to November, and, because of the high phosphorus concentrations and its ability to fix nitrogen, is able to reach seasonally high biomass levels that eventually produce highly degraded water quality (Boyd et al. 2002, p. 34). As a result of photosynthesis during algal blooms, pH levels increase to stressful levels for fish (Wood et al. 2006, p. 1). Once the algal bloom subsides, decomposition of the massive amounts of biomass can lower dissolved oxygen to levels harmful or fatal to fish (Perkins et al. 2000, pp. 24-25; Wood et al. 2006, p. 1). Additionally, other cyanobacteria (Microcystis sp.) may produce toxins harmful to sucker liver tissue (VanderKooi et al. 2010, p. 2). Special management considerations or protection are therefore needed to protect water quality from the deleterious effects of algal blooms and may include reducing excess phosphorus concentrations by fencing cattle out of riparian areas, reconfiguring agricultural waterways, increasing riparian stands of vegetation, and restoring wetland habitat that is crucial for filtering sediment and nutrients. Hydrographs of both Clear Lake Reservoir and Upper Klamath Lake exhibit patterns of a snow-melt-driven system with highest inflows and levels during spring and early summer, although groundwater also is a significant contributor to Upper Klamath Lake (Gannett et al. 2007, p. 1). However, Clear Lake Reservoir, Gerber Reservoir, and Upper Klamath Lake are managed to store and divert water for irrigation every year. Clear Lake Reservoir is highly sensitive to drought and downstream water delivery because of its small watershed, low precipitation, minimal groundwater input, and high evaporation rates (NRC 2004, p. 129). In the dry years of 1991 and 1992, the level of Clear Lake Reservoir was drawn down to extremely low levels for irrigation supply (Moyle 2002, p. 201). In 1992, Lost River sucker within Clear Lake Reservoir that were examined exhibited signs of stress, including high rates of parasitism and poor body condition (NRC 2004, p. 132). These signs of stress began to decline as the water level in Clear Lake Reservoir rose in 1993, at the end of the drought (NRC 2004, p. 132). In 2009, when lake levels were again low due to drought, diversions from Clear Lake Reservoir were halted in mid-summer, and there were no diversions again in 2010 in order to comply with the biological opinion's requirements for minimum lake elevations to avoid harm to listed fish. Likewise, the amount of available larval habitat and suitable shoreline spring spawning habitat in Upper Klamath Lake is significantly affected by even minor changes in lake elevation (Service 2008, p. 79). Therefore, special management considerations or protection are needed to address fluctuations in water levels due to regulated flow and lake elevation management. Special management may include the following actions: Managing bodies of water such that there is minimal flow departure from a natural hydrograph; maintaining, improving, or reestablishing instream flows to improve the quantity of water available for use; and managing groundwater use. The effects of fluctuations in water levels due to regulated flow management may affect the ability of Lost River sucker and shortnose sucker to access refugia during periods of poor water quality. For example, Pelican Bay appears to act as a key refugium during periods of poor water quality, and efforts to maintain the quality and quantity of the habitat there may be beneficial for suckers (Banish et al. 2009, p. 167). Therefore, special management considerations or protections are needed to address access to refugia and may include the following: Maintaining appropriate lake depths to allow access to refugia; restoring degraded habitats to improve quantity of flow at refugia as well as refugia quality; and maintaining or establishing riparian buffers around refugia to improve refugia water quality. The Klamath Project (Project) stores and later diverts water from Upper Klamath Lake for a variety of Project purposes. These operations result in fluctuating lake levels and flows at the outlet of the lake that differ from historic conditions, some of which increase movement of juvenile fish downstream of Upper Klamath Lake. As such, special management considerations or protection may be needed to address the timing and volume of water that is diverted to maintain sufficient lake elevations. Throughout the Upper Klamath Lake and Lost River Basin, timber harvesting and associated activities (road building) by Federal, State, tribal, and private landowners have resulted in soil erosion on harvested lands and transport of sediment into streams and rivers adjacent to or downstream from those lands (Service 2002, p. 65; NRC 2004, pp. 65-66). Past logging and road-building practices often did not provide for adequate soil stabilization and erosion control. A high density of forest roads remains in the upper Klamath River basin, and many of these are located near streams where they likely contribute sediment (USFS 2010, p. 7). These sediments result in an increase of fine soil particles that can cover spawning substrata. The major agricultural activity in the upper Klamath River basin, livestock grazing, also has likely led to an increase in sediment and nutrient loading rates by accelerating erosion (Moyle 2002, p. 201; Service 2002, pp. 56, 65; McCormick and Campbell 2007, pp. 6-7). Livestock, particularly cattle, have heavily grazed floodplains, wetlands, forests, rangelands, and riparian areas, and this activity has resulted in the degradation of these areas. Poorly managed grazing operations can alter the streamside riparian vegetation and compact soil surfaces, increasing groundwater runoff, lowering streambank stability, and reducing fish cover. The increase in sediment accumulation and nutrient loading is consistent with the changes in land use in the upper Klamath River basin occurring over the last century (Bradbury et al. 2004, pp. 163- 164; Eilers et al. 2004, pp. 14-16). Therefore, special management considerations or protection may be required to improve water quality and include: Reducing sediment and nutrient loading by protecting riparian areas from agricultural and forestry impacts, reducing road density to prevent excess sediment loading, and improving cattle management practices. Lost River sucker and shortnose sucker have limited hydrologic connection to spawning or rearing habitat. For example, lake levels in Clear Lake Reservoir in conjunction with flows in Willow Creek, the sole spawning tributary (Barry et al. 2009, p. 3), may adversely affect sucker populations during the spawning migration. Lake levels may be especially pertinent during years when spring runoff is intermediate and flows are sufficient for spawning migration by the suckers, but are not sufficient enough to increase lake elevations substantially during the narrow spawning window. This situation could create a condition in which flow is adequate for both species to spawn but lake elevation precludes suckers ability to access the habitat, although further research is needed to clarify this dynamic. Likewise, the amount of suitable shoreline spring spawning habitat in Upper Klamath Lake is significantly affected by even minor changes in lake elevation, but it is unknown exactly how such levels directly affect annual productivity. Several shoreline spring-spawning populations, including Harriman Springs and Barkley Springs, have been lost or significantly altered due to railroad construction (Andreasen 1975, pp. 39-40; NRC 2004, p. 228). Historically, wetlands comprised hundreds of thousands of hectares throughout the range of the species (Gearhart et al. 1995, pp. 119-120; Moyle 2002, p. 200; NRC 2004, pp. 72-73), some of which likely functioned as crucial habitat for larvae and juveniles. Other wetlands may have played vital roles in the quality and quantity of water. Loss of ecosystem functions such as these, due to alteration or separation of the habitat, is as detrimental as physical loss of the habitat. Roughly 66-70 percent of the original 20,400 ha (50,400 ac) of wetlands surrounding Upper Klamath Lake was diked, drained, or significantly altered beginning around 1889 (Akins 1970, pp. 73-76; Gearhart et al. 1995, p. 2; Larson and Brush 2010, p. 19). Additionally, of the approximately 13,816 ha (34,140 ac) of wetlands connected to Upper Klamath Lake, relatively little functions as rearing habitat for larvae and juveniles, partly due to lack of connectivity with current spawning areas (NRC 2004, pp. 72-73). Therefore, special management considerations or protection may be needed for water quantity to improve access to spawning locations and quality and quantity of wetlands used as rearing habitat. This may be accomplished by: Improving lake level management to allow access to spawning locations during late winter and early spring, restoring access to wetland rearing habitat, and creating wetland rearing habitat adjacent to lakes and reservoirs. The exotic fish species most likely to affect Lost River sucker and shortnose sucker is the fathead minnow. This species may prey on young Lost River sucker and shortnose sucker and compete with them for food or space (Markle and Dunsmoor 2007, pp. 571-573). For example, fathead minnow were first documented in the upper Klamath River basin in the 1970s and are now the numerically dominant exotic fish in Upper Klamath Lake (Simon and Markle 1997, p. 142; Bottcher and Burdick 2010, p. 40; Burdick and VanderKooi 2010, p. 33). Additional exotic, predatory fishes found in sucker habitats, although typically in relatively low numbers, include yellow perch (Perca flavescens), bullhead (Ameiurus species), largemouth bass (Micropterus salmoides), crappie (Pomoxis species), green sunfish (Lepomis cyanellus), pumpkinseed (Lepomis gibbosus), and Sacramento perch (Archoplites interruptus) (NRC 2004, pp. 188-189). In addition to exotic fish species, recent information has shown that American white pelican (Pelecanus erythrorhynchos) and double-crested cormorant (Phalacrocorax auritus) prey on Lost River sucker and shortnose sucker (Burdick 2012, p. 1). Special management considerations or protection may be needed to protect the forage base from predation by exotic fish species and could be accomplished by the following: Reducing conditions that allow exotic fishes to be successful and restoring conditions that allow Lost River sucker and shortnose sucker to thrive; conducting evaluations to determine methods to remove exotic fish species; determining methods to reduce avian predation; and determining methods to reduce or eliminate competition for the forage base upon which Lost River sucker and shortnose sucker depend to survive.

Life History

Feeding Narrative

Adult: Shortnose suckers are specialized invertivores that predominantly feed on zooplankton and macroinvertebrates. The species is known to be active at night during seasonal migrations. Fathead minnows (Pimephales promelas) are known to prey on Shortnose sucker larvae (USFWS 2013b). Larvae are typically completely transformed into juveniles by mid-July, measuring about 25 mm (1 in.) in total length. Shortnose suckers captured at pre-spawn staging areas in Upper Klamath Lake and in the Williamson and Sprague Rivers exhibited growths in fork length of 4.2 mm (0.17 in.) per year for males and 3.7 mm (0.15 in.) per year for females (USFWS 2013b).Availability of zooplankton and macroinvertebrates, as well as the stream and lake systems that support them, are required for the survival of shortnose suckers. Shortnose suckers have also been observed feeding on algae and aquatic insects (USFWS 2013a; USFWS 2013b).

Reproduction Narrative

Adult: Shortnose sucker females broadcast their unfertilized eggs typically in the company of two males, who fertilize the eggs. The fertilized eggs then settle in the top few inches of the substrate. Females are highly fecund, producing 18,000 to 72,000 eggs per female per year, of which only a very small percentage survive to become juveniles. The species leaves its offspring to fend for themselves after laying eggs. Hatching occurs around 1 week after fertilization. Approximately 10 days after hatching, larvae emerge out of the gravel. Larvae spawned in streams quickly drift downstream into lake habitat, beginning in April through July. Sexual maturation occurs within 4 to 6 years, and it appears that most adults spawn every year. The average lifespan for the species is 11 to 13 years, with maximum ages recorded at up to 33 years. River spawning runs from Upper Klamath Lake, beginning when river temperatures reach 12 °C (54 °F), typically in mid-April; they may also spawn in springs from February to late April when water temperatures are a constant 15 °C (60 °F). The species requires gravel substrates in habitats less than 1.3 m (4.3 ft.) deep in tributary streams and rivers (USFWS 2013a; USFWS 2013b).

Geographic or Habitat Restraints or Barriers

Adult: Dams lacking a suitable fishway, high waterfalls, and upland habitats (NatureServe 2015).

Spatial Arrangements of the Population

Adult: Uniform

Environmental Specificity

Adult: Narrow/specialist.

Tolerance Ranges/Thresholds

Adult: High

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: Requires emergent vegetation for cover.

Habitat Narrative

Adult: Habitat for the species includes deep-water lakes and impoundments, and swift water and deep pools of small to medium rivers. The species occurs in riverine and palustrine habitats, as well as marsh and shoreline regions. Suckers can be found throughout the reservoirs they inhabit, but they appear to prefer shorelines with emergent vegetation that can provide cover from predators and invertebrate food. Dams lacking a suitable fishway, high waterfalls, and upland habitats can act as barriers for the species. The species is uniformly arranged. Suckers move from lakes into tributary streams to spawn in riffles or runs with gravel or cobble substrate, moderate flows, and depths of 21 to 128 centimeters (8.3 to 50.4 in.) in the benthic zone of river and lake systems. Spawning also occurs along the shore of Upper Klamath Lake (e.g., at spring inflows). Juveniles move downstream into lakes soon after hatching. Adult shortnose suckers inhabit lake environments with water depths of 1 to 4.5 m (3.2 to 14.7 ft.), but appear to prefer depths from 1.5 to 3.4 m (4.9 to 11.1 ft.). As shortnose suckers mature, they tend to use deeper, less vegetated habitats in the lakes and reservoirs they inhabit, although these areas are still relatively shallow (USFWS 2013a; USFWS 2013b; NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: High

Migratory vs Non-migratory vs Seasonal Movements

Adult: Seasonal movements/migrations to spawning habitats.

Dispersal

Adult: During the spring, adults migrate into tributaries of the lakes and reservoirs to spawn in small groups. In Upper Klamath Lake, migrations begin as water temperatures warm in April and May (USFWS 2013b).

Immigration/Emigration

Adult: No

Dispersal/Migration Narrative

Adult: Shortnose suckers are highly mobile fish that migrate seasonally to their spawning habitats. The species does not immigrate nor emigrate. Out-migrating larvae (those larvae that have hatched and begun to drift downstream) and spawn-ready adults use river and stream habitat as a migration corridor. Downstream movement mostly occurs at night near the water surface (USFWS 2013b).

Additional Life History Information

Adult: Downstream movement mostly occurs at night near the water surface (USFWS 2013b).

Population Information and Trends

Population Trends:

Long-term trend: declining (USFWS 2013b). If current conditions continue, we also expect the shortnose sucker population in Upper Klamath Lake to become extirpated within the next 30-40 years. Projections suggest that this population will decline 78% over the next 10 years to a level below 5,000 individuals. This would result in only two populations remaining for the species, both of which are highly genetically introgressed with the Klamath largescale sucker and geographically isolated behind dams without fish passage. Both species are likely to realize reduced risk of extinction from implementation of the rearing program, but landscape-scale improvements to nutrient loads in Upper Klamath Lake will be necessary to achieve full recovery. The dire conditions of Lost River sucker in Clear Lake Reservoir suggest that recovery of the species will likely be unattainable without additional recovery efforts in this waterbody. Recovery of the species is likely to require substantially more drastic actions than the few considered here. Recovery of shortnose sucker appears more achievable in the Lost River sub-basin under the scenarios assessed, but uncertainties about the overall impacts of genetic introgression remain (USFWS, 2019).

Species Trends:

Long-term trend: decline greater than 50 percent (NatureServe 2015; USFWS 2013b).

Resiliency:

Overall resiliency for Lost River sucker is generally low, primarily because redundancy is critically low. There are only three distinct spawning populations: Upper Klamath Lake-springs, Upper Klamath Lakeriver, and Clear Lake Reservoir. Two of the remaining populations (Clear Lake Reservoir and Upper Klamath Lake-springs) have very low numbers and are at a high risk of localized catastrophic events. The Clear Lake Reservoir population is completely separate from the others. As a species, Lost River sucker appear to be relatively genetically distinct from the other sucker species in the basin (USFWS, 2019).

Representation:

Representation of diversity within and among populations of each species is difficult to quantify. Hybridization and introgression between shortnose sucker and Klamath largescale sucker is well documented, and evidenced by phenotypic intermediates in morphology (Markle et al. 2005 p. 476) and lack of discrimination among molecular markers (Dowling et al. 2016 p. 19). However, morphological distinctiveness of the species varies by location (Markle et al. 2005 p. 476). Spawning between these species is partially isolated temporally and spatially (Markle et al. 2005 p. 480). In Upper Klamath Lake morphological attributes of both species are more or less maintained, while other populations such as Gerber and Clear Lake reservoir show a spectrum of morphological intermediates (Dowling 2005 pp. 21 & 22). Despite genetic evidence of hybridization, the access to a diversity of habitats presumably maintains phenotypes of both species to some degree. Genetic representation is lower for both species in Clear Lake Reservoir as compared to conspecifics in Upper Klamath Lake. In this reservoir, both species have lower heterozygosity and allelic richness compared to conspecifics in Upper Klamath Lake (Smith and VonBargen 2015 p. 24). Lower genetic diversity could be due to the population being derived from a limited number of individuals trapped when the dam was installed (i.e., founder effects) or simply due to genetic drift associated with small population size. Additionally, lack of connectivity with other populations also further depresses genetic diversity via reduced gene flow. Of more importance, the shortnose sucker population in Clear Lake Reservoir is highly introgressed with Klamath largescale sucker (Tranah and May 2006 p. 313, Dowling et al. 2016, entire). Shortnose sucker are more genetically similar to Klamath largescale within the same subbasin than they are to conspecifics from the other subbasin (Smith and VonBargen 2015 p. 14). Within the Lost River subbasin, shortnose sucker and Klamath largescale sucker can be difficult to distinguish morphologically. This can potentially erode species distinctiveness (genetic representation) within the population as well as reduce the abundance of phenotypic shortnose sucker (i.e., abundance of individuals that possess the morphology associated with shortnose sucker and thereby reduce the overall resiliency of the species within the reservoir). Genetic representation within the Gerber Reservoir population is very similar to that of Clear Lake Reservoir. The shortnose sucker are highly introgressed with Klamath largescale, and the population is isolated from other populations. Unlike the shortnose sucker, hybridization and introgression involving the endangered Lost River sucker does not appear to be extensive (Dowling et al. 2016 p. 18). At present, both endangered suckers in Upper Klamath Lake possess population sizes large enough to maintain genetic diversity and prevent the negative effects of inbreeding. We cannot make similar conclusions about other populations because we lack accurate estimates of population sizes. The draining of Tule Lake and Lower Klamath Lake and the construction of dams and irrigation structures has isolated the populations such that there is no exchange of individuals between the major remaining populations in Upper Klamath Lake, Gerber Reservoir, and Clear Lake, and the system no longer functions as a metapopulation. This reduction of redundancy and connectivity could also have negative impacts on representation of diversity within the species. Maintenance of ecological and phenotypic distinction between shortnose sucker and Klamath largescale in Upper Klamath Lake suggest that introgression between these species does not threaten the resiliency of the endangered shortnose sucker population in Upper Klamath Lake. However, the resiliency of the shortnose sucker populations in Clear Lake Reservoir and Gerber Reservoir may be even less than it appears because few individuals possessing the distinct genetics and ecology of the species occur (USFWS, 2019).

Redundancy:

Redundancy of populations for these species has always been relatively low. Pre-settlement populations probably numbered no more than four for each species. Redundancy for both species has been greatly reduced due to the destruction of at least two major populations (Lower Klamath Lake and Tule Lake) as well as numerous subpopulations or spawning locations, namely at springs throughout Upper Klamath Lake and the Lost River. The draining of Tule Lake and Lower Klamath Lake for agricultural use essentially eliminated two of the major water bodies inhabited by both species. Lower Klamath Lake populations are completely extirpated and Tule Lake has a very small number of individuals that lack access to suitable spawning habitat. Because of this, Tule Lake does not provide substantial redundancy for the species. These water bodies represented two of the three major lake/marsh complexes in the Upper Klamath Basin; the remaining one is Upper Klamath Lake, which supports the largest extant populations of both species. Although large swaths of habitat were destroyed throughout the range of the species, some of the developments for agricultural use increased available habitat for Lost River and shortnose suckers. In particular, Clear Lake was enlarged and lake elevations were stabilized by the creation of Clear Lake Reservoir. This increased the amount of accessible habitat available for this population, but it is unclear how this may have also affected the quality of habitat – for better or for worse. Clear Lake Reservoir supports populations of both Lost River and shortnose sucker at present. Additionally, the construction of a dam on Miller Creek to create Gerber Reservoir in the Lost River drainage created new lacustrine habitat in the reservoir that currently supports a population of shortnose sucker. Reservoirs constructed for hydropower production along the main stem of the Klamath River also support small numbers of suckers, but there is no evidence that these populations reproduce. Removal of these Klamath River dams under consideration so it is very unlikely that these populations will provide redundancy for the species in the future. Suckers were historically able to move among the various lake habitats, at least during periods of high water. There are important differences in the status and threats to the remaining populations, so the details for each location are discussed separately. In terms of redundancy within a population, only the Lost River sucker in Upper Klamath Lake currently have more than one substantial spawning subpopulations. This provides some redundancy, albeit small, because of the low number of spring-spawners and the temporal and spatial overlap of spawners and adult habitat. For example, climate change will likely reduce snow pack and therefore reduce spring runoff in the river because of warmer temperatures and more precipitation falling as rain (Markstrom et al. 2012, entire, Risley et al. 2012, entire). These changes may reduce spawning success in the Williamson and Sprague Rivers, but are unlikely to impact the groundwater seeps in the same way. There are four primary spawning areas along the eastern shoreline (Sucker, Silver Building, Ouxy, and Cinder springs), which are all within 6 km (3.7 mi) of each other. This proximity makes these spawning sites of reduced utility in resisting catastrophic disturbances. In addition to these extant spawning locations, there were additional historical spawning subpopulations at Barkley Springs, Harriman Springs and likely other springs throughout Upper Klamath Lake. These subpopulations have disappeared completely, greatly reducing the redundancy within the population. This loss increases the sensitivity of the population to widespread or catastrophic disturbances. Both species in Clear Lake are entirely dependent on the Willow Creek watershed for spawning habitat. Lost River sucker utilize the lower portions of the creek as far as the confluence with Boles Creek, as well as Boles Creek (a tributary to Willow Creek) as far as Avanzino Reservoir (approximately 43 km [27 mi]). Shortnose sucker ascend both Willow Creek and Boles Creek much further than LRS (approximately 143 km [89 mi]). This provides a small amount of resilience for the SNS population in Clear Lake Reservoir, but the linkage between the two streams suggests that the redundancy benefit provided is minimal. It is not clear why LRS do not utilize the higher reaches of Willow Creek, especially because LRS are the species that travel the greater distance in the Sprague River. There are at least two distinct spawning tributaries for shortnose sucker in the Gerber Reservoir system: Barnes Valley Creek and Ben Hall Creek. Approximately 88 percent of the adults leaving Gerber Reservoir to spawn ascend Barnes Valley Creek. The presence of two spawning streams creates some redundancy within the population that may help to increase the probability of successful spawning each year, as well as reduce the risk of localized catastrophic events, but the unbalanced utilization of the sites may reduce that benefit somewhat. Listed Klamath suckers also occur in small numbers in a handful of other waterbodies. These populations consist almost exclusively of shortnose sucker, but also include a handful of Lost River sucker. The shortnose sucker are found in Lake Ewauna, Tule Lake, the main stem reservoirs, and the Lost River proper (Shively et al. 2000 pp. 82–86). Lake Ewauna probably functions as a subpopulation to Upper Klamath Lake to some degree. Hundreds of listed suckers (both species) have been captured, tagged, and translocated to Upper Klamath Lake from Lake Ewauna since 2010 (Kyger and Wilkens 2011 p. 3; N. Banet, U.S. Geological Survey, personal comment). Similarly, hundreds of individuals of both species were captured in Tule Lake during a three-year effort (Hodge and Buettner 2009 pp. 4–6). A two-year effort in the main stem reservoirs on the Klamath River (Desjardins and Markle 2000 pp. 14 & 15) produced slightly more than 200 captures, 99 percent of which were shortnose sucker. The number of catches given the effort suggests that these populations possess very few individuals. Lost River sucker only occur in Tule Lake in addition to the populations discussed above (Shively et al. 2000 pp. 87–89). All of these minor populations possess extremely low resiliency due to a combination of degraded habitat, low numbers, and restricted access to suitable spawning habitat (USFWS, 2019).

Population Growth Rate:

Stable

Number of Populations:

Two: Upper Klamath Lake and Clear Lake Reservoir (USFWS 2013b).

Population Size:

~19,000 (USFWS, 2019)

Adaptability:

Low

Additional Population-level Information:

Currently, the best available information indicates that the age distribution of adults in some populations primarily comprises older individuals because juveniles are not surviving to maturity. Because of the generally dispersed distribution of shortnose sucker and the extensive habitat, accurate estimates of population size are extremely difficult to obtain. Additionally, most populations have not been monitored sufficiently to produce adequate data to even attempt a reasonable estimate of population size. In 2011, Upper Klamath Lake monitoring detected or captured approximately 6,000 tagged shortnose suckers participating in the annual spawning congregations and runs. Estimates of what proportion of the total population is tagged are unavailable, but data suggest that shortnose sucker number fewer than 25,000 in Upper Klamath Lake (USFWS 2013b).

Population Narrative:

This species is represented by only two populations that are sustaining themselves without the input of larvae or older suckers from other areas: Upper Klamath Lake and Clear Lake Reservoir. Long-term monitoring of shortnose sucker spawning populations in Upper Klamath Lake has revealed several trends in abundance and demography, including consistent annual declines in the number of individuals participating in the runs and an increasing trend in the average size (and therefore age) of spawning adults. The long-term trend is a decline greater than 50 percent. Survivorship in Upper Klamath Lake appears to have been relatively low in the early 2000s. Recruitment in Upper Klamath Lake was essentially nil in 1997 through 2004. Populations in Gerber Reservoir and Clear Lake show evidence of frequent recent recruitment and declines in the number of large adults. The small population in the Tule Lake sumps appears to be isolated from suitable spawning habitat, and likely is not self-sustaining (NatureServe 2015; USFWS 2013b).Total adult population size is unknown but likely exceeds 10,000. Currently, the best available information indicates that the age distribution of adults in some populations primarily comprises older individuals because juveniles are not surviving to maturity. Because of the generally dispersed distribution of shortnose sucker and the extensive habitat, accurate estimates of population size are extremely difficult to obtain. Additionally, most populations have not been monitored sufficiently to produce adequate data to even attempt a reasonable estimate of population size. In 2011, Upper Klamath Lake monitoring detected or captured approximately 6,000 tagged shortnose suckers participating in the annual spawning congregations and runs. Estimates of what proportion of the total population is tagged are unavailable, but data suggest that shortnose sucker number fewer than 25,000 in Upper Klamath Lake (NatureServe 2015; USFWS 2013b). Upper Klamath Lake contains the largest remaining populations of both Lost River and shortnose suckers with approximately 100,000 adult Lost River sucker river-spawners, 8,000 adult Lost River sucker shoreline-spring-spawners, and 19,000 adult shortnose suckers (Figure 14). (USFWS, 2019)

Threats and Stressors

Stressor: Loss of habitat
Exposure: Direct loss of habitat.
Response: Populations are fragmented and possibly extirpated.
Consequence: Reduced viability; reduced number of healthy, viable populations (redundancy); and drastically decreased numbers range-wide.
Narrative: Loss of habitat was a major factor leading to the listing of the shortnose sucker. Historic habitat loss was especially pronounced in the Lost River–Tule Lake and Lower Klamath subbasins, where approximately 150,000 ac. (60,700 ha) (approximately 77 percent) of habitat were lost when Tule Lake and Lower Klamath Lake were drained early in the 20th century. These lakes functioned as catchments for larval and juvenile suckers emigrating out of Upper Klamath Lake or drifting downstream from the Lost River. Loss of these habitats has reduced the viability of the species by reducing the number of healthy, viable populations (redundancy) and drastically decreasing the numbers of shortnose suckers range-wide. Loss of these areas has restricted the species to only three populations that are able to achieve even marginal reproduction (Upper Klamath Lake, Gerber Reservoir, and Clear Lake Reservoir). This puts the species at significant risk of catastrophic events, such as die-offs, given the lack of population redundancy that could be used to replenish affected populations. Access to important habitat areas for spawning, rearing, and other needs has also been greatly curtailed. About 70 percent of the original 50,000 ac. of wetlands surrounding Upper Klamath Lake were diked and drained between 1889 and 1971, leaving about 16,000 ac. in 1990 connected to the lake. These wetlands are important as rearing habitat for larval and juvenile suckers, and the loss of access to such habitats may cause use of unsuitable habitats by these life stages (USFWS 2013b).

Stressor: Adverse water quality
Exposure: Large amounts of dissolved nutrients; algal blooms.
Response: Mortality events.
Consequence: Reduction in population, extirpation, and habitat loss and degradation.
Narrative: Lake suckers such as shortnose suckers are relatively tolerant of water quality conditions unfavorable for many other fishes, tolerating higher pH (more basic conditions), temperatures, and unionized ammonia concentrations; and lower dissolved oxygen concentrations. Nevertheless, many of the water bodies currently occupied by shortnose suckers periodically possess conditions that are potentially harmful or fatal to the species. Much of this is due to large amounts of dissolved nutrients which promote biological productivity, such as algal growth. Throughout the year, the dynamics of algal blooms affect dissolved oxygen levels (ranging between anoxic to supersaturated conditions), pH, and unionized ammonia, all of which can impact fish health and survival. These processes are particularly important in Upper Klamath Lake and Keno Reservoir. Upper Klamath Lake was naturally highly productive or eutrophic prior to European settlement, but has since become even more productive or "hypereutrophic." Nutrients driving biological production in Upper Klamath Lake originate from external sources (such as water pumped from diked wetlands and run-off from agriculture and roads) and internal sources (namely lake sediments). The accumulation of nutrient-bearing sediments in Upper Klamath Lake has dramatically increased during the 20th century, and these "modern" sediments are higher in nitrogen and phosphorus than pre-settlement sediment, suggesting that even though sediments are a natural source of nutrients, the current levels are probably higher than

they would have been without anthropogenic (human-generated) influences USFWS 2013b).

Stressor: Algae growth
Exposure: Cyanobacteria blooms.
Response:
Consequence: Mortality, population decline, and extirpation.
Narrative: In conjunction with increased nutrient loading, significant alterations to shortnose sucker habitat in Upper Klamath Lake have occurred over the last century due to changes in the algal community. Core samples of bottom sediments indicate that the cyanobacterium AFA was not present in Upper Klamath Lake prior to the 1900s. It now dominates the algal community, and because of the high concentrations of nutrients available (as well as its ability to fix nitrogen), it is able to reach seasonally high densities that cause degraded water quality. Aphanizomenon flos-aquae often occurs in massive blooms, constituting more than 90 percent of the biomass of photosynthetic organisms in the lake during the summer. High photosynthetic activity can supersaturate the water with dissolved oxygen during daylight hours, and subsequent respiration at night can deplete dissolved oxygen levels. Both supersaturation and depletion of dissolved oxygen can be detrimental to shortnose suckers (USFWS 2013b).

Stressor: Habitat degradation and restoration
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Approximately 400 habitat restoration projects have been recently completed or are being planned in the upper Klamath River basin. Because such efforts are relatively recent, population-level responses by shortnose suckers are not yet apparent. The foremost project that has occurred since the previous 5-year Status Review of this species is the restoration of the delta where the Williamson River enters Upper Klamath Lake. Shortnose suckers have been documented using portions of the approximately 6,000 ac. (2,430 ha) of potential larvae and juvenile rearing habitat that were restored in 2007 and 2008. Although more time will be needed for the area to recover to its previous natural state due to the subsidence from agricultural use, this is still a major advancement toward the recovery of the shortnose sucker. Another significant recovery action that occurred in the past 5 years was the removal of Chiloquin Dam on the Sprague River in 2008. The dam was identified in the 1988 listing as a threat to shortnose suckers because it was thought to block access to upstream spawning areas. Removal effectively unblocks approximately 120 km (75 mi.) of the Sprague River for spawning and migration of adults and larvae. However, insufficient time has passed to completely assess the overall effects on the population (USFWS 2013b).

Stressor: Nonnative fishes
Exposure: Fathead minnows.
Response: Predation
Consequence: Lower survival rates.
Narrative: Nonnative fishes are a potential threat through predation or as sources of exotic diseases/parasites. Controlled experiments have demonstrated that adult fathead minnows (Pimephales promelas) prey on sucker larvae. In Upper Klamath Lake, higher fathead minnow abundance was negatively associated with shortnose sucker survival rates. These data suggest that predation by highly abundant fathead minnows may be an important threat to larval sucker survival, which may be exacerbated by the loss of emergent wetland habitat that provides cover

for shortnose sucker larvae. Other nonnative fishes may also pose a threat to shortnose suckers; however, little quantitative information exists to indicate their influence on shortnose sucker abundance and distribution (USFWS 2013b).

Stressor: Predation
Exposure: Birds
Response: Predation
Consequence: Avian predation can be responsible for mortality of at least 8.4 precent of juveniles and 4.2 prescent of adults annually in Clear Lake (Evan et al. 2016).
Narrative: Several species of birds may prey on shortnose suckers, but the ultimate effect to the status of the species from these avian predators is currently unknown. In Clear Lake Reservoir, radio-tags and Passive Integrated Transponders (PIT tags, used for tracking) of individual shortnose suckers have been located on islands associated with nesting colonies of American white pelicans (Pelecanus erythrorhynchos), double-crested cormorants (Phalacrocorax auritus), and great blue herons (Ardea herodias). Adult shortnose suckers are susceptible to avian predation during the spawning run, when they are congregated in a small area (such as Willow Creek, the main spawning tributary to Clear Lake Reservoir) and occur in shallower water relative to larger bodies of water. Such predation on spawning adults may increase mortality rates of this crucial life stage, but it may also cause altered behavior during this critical period. For example, predation on adults at spawning sites may limit the amount of time spent on the spawning ground. Throughout the range of the species there are also numerous species of piscivorous birds, including terns, grebes, and mergansers, that can target juvenile and larvae shortnose suckers (USFWS 2013b).

Stressor: Parasites
Exposure: Anchor worm parasitism.
Response: Mortality, vectors for pathogens, and increased susceptibility to predation.
Consequence: Unknown
Narrative: Information suggests that parasites could be a threat to the suckers. Anchor worm parasitism on age-0 shortnose suckers appears to be highly variable from year to year in Upper Klamath Lake. From 1994 through 1996, the percent of age-0 suckers (all species) parasitized by anchor worms ranged from 0 percent to 7 percent, but from 1997 through 2000 it increased to between 9 and 40 percent. The term “age-0” refers to individuals that have lived less than one year, but is most often used in reference to juveniles. In 2008, only 4 percent of captured juvenile suckers were infected with external parasites, but this jumped to 18 percent in 2009. Parasites can lead to direct mortality, provide a route for pathogens to enter fish (since they create a wound), or can make fish more susceptible to predation. We currently do not have enough information to accurately assess the degree to which parasites negatively impact shortnose sucker survival and productivity (USFWS 2013b).

Stressor: Toxins
Exposure: Blue-green algal toxins.
Response: Adverse effects on organs, and mortality.
Consequence: Unknown
Narrative: The potential impacts of the blue-green algal or cyanobacteria toxins Microcystin have recently come to light. Microcystin is a toxin produced by Microcystis aeruginosa that primarily affects the liver of suckers (all species); it causes a variety of symptoms, but can also affect the intestines, kidneys, heart, spleen, and gills. In a 2007 survey, 49 percent of a sample of juvenile

suckers (all species) from Upper Klamath Lake (n = 47) collected at 11 shoreline sites exhibited indications of microcystin exposure. One hypothesis is that the toxin is secondarily ingested when suckers consume midge larvae (Chironomidae), which feed on the algae. Further investigations are required to better understand the degree to which these toxins threaten the shortnose suckers in Upper Klamath Lake (USFWS 2013b).

Stressor: Regulatory Mechanisms
Exposure: Inadequacy of existing regulatory mechanisms.
Response: Loss of habitat or habitat degradation from populations, and potential populations not being properly identified and maintained.
Consequence: Reduction in population, extirpation, and habitat loss and degradation.
Narrative: The Endangered Species Act (ESA) is the primary federal law that provides protection for this species since its listing as endangered in 1988. Other federal and state regulatory mechanisms provide protections for the species based on current management direction, but do not guarantee protection for the species absent its status under ESA, with the exception of the ESAs for each state. In general, these regulatory mechanisms provide protections to the species by restricting take (state ESAs), by requiring review of actions that may impact the species, and by providing broad-scale improvements to habitat or other means that affect habitat. Nevertheless, other laws and regulations have limited ability to protect the species in absence of ESA (USFWS 2013b).

Stressor: Entrainment
Exposure: Water management structures and unscreened diversions.
Response: Fish perish after becoming trapped.
Consequence: Population decline.
Narrative: Movement of fish into irrigation systems is a threat to the suckers. Thousands of suckers, including some adults, were entrained into the A-Canal, the largest diversion in the upper basin, near the Link River Dam. Although some of these fish were salvaged, many likely died. The impact of entrainment into the irrigation system of the Klamath Project was reduced by construction of screening facilities over the A-Canal, although larvae are still at risk. Under the present design, fish screened from entering the A-Canal are returned via pipeline to Upper Klamath Lake at a point that is near the river gates of the Link River Dam. Further investigations are needed to determine the overall effects and stress on transferred fish, and whether fish expelled through the pipeline remain in Upper Klamath Lake or are subsequently entrained by flows through the Link River Dam. Substantial entrainment occurs at the river gates of the Link River Dam. Currently, these gates have no structures to prevent drawing fish downstream, but the East Side and West Side hydroelectric diversion facilities (operated by PacifiCorp) are currently shut down between July 15 and November 15 to reduce entrainment when vulnerable life stages of listed suckers are present. During the late summer of 2006, more than 3,500 age-0 juvenile suckers were collected in the Link River just below the dam, with intermittent sampling of a fraction of the channel. The Committee on Endangered and Threatened Fishes in the Klamath River Basin of the National Research Council recommended screening to prevent downstream losses at Link River Dam. Nonetheless, further research is required to better quantify the threats these structures pose to recovery (USFWS 2013b).

Stressor: Climate Change
Exposure: Global and regional changes in climate.
Response: See narrative.

Consequence: See narrative.
Narrative: Climate variability, such as fluctuations between wet and dry periods, is part of natural processes; however, climatic models suggest that much of the recent trends in climate is driven by anthropogenic causes. A suite of climate models predicts that over the next 100 years the mean flow of the Sprague River will increase during winter months but decrease during the spawning period, a pattern which is likely to be exhibited throughout the upper Klamath Basin. It is difficult to accurately predict how such climatic changes will affect the shortnose sucker. These species are adapted to withstand periodic droughts, but given the current reduced state of the species, they may be negatively impacted if there is an increase in the intensity or frequency of droughts, or a substantial shift in the timing of snowmelt and runoff. Likewise, detrimental changes in refugia availability or community composition may also accompany climate change (USFWS 2013b).

Recovery

Reclassification Criteria:
Current spawning and rearing habitat is maintained, and improved access ensures annual use (USFWS 2013a).

A range-wide Spawning and Rearing Enhancement Plan has been developed and implemented. This plan shall identify and prioritize areas of potential spawning and rearing habitat for enhancement and/or restoration, including areas which are degraded or unavailable due to lack of connectivity or passage (USFWS 2013a).

Connectivity and access is ensured to habitats that provide refuge to suckers to avoid poor water quality (particularly Pelican Bay) during the months of July, August, and September – Upper Klamath Lake Recovery Unit (USFWS 2013a).

Natural vegetated wetland areas are restored, including in-stream, wetland, and riparian areas around the mouth of Willow Creek where it meets Clear Lake Reservoir and throughout its drainage—Clear Lake Reservoir Management Unit (USFWS 2013a).

Newly identified or clarified effects of predation and disease are minimized through implementation of recommendations from ongoing scientific research, which clarifies the interaction of shortnose sucker with predators and pathogens (USFWS 2013a).

An Entrainment Reduction Plan has been developed and implemented. This plan shall identify and prioritize screening of diversions throughout upper Klamath Basin, including the Klamath Project, and propose strategies for efficient reduction of entrainment (USFWS 2013a).

Development and implementation of a plan to assess, monitor, and improve juvenile and sub-adult vital rates and demography, including threats and negative impact reduction. This plan shall also designate specific demographic or vital rate targets, and strategies for achieving these targets, important for downlisting and delisting (USFWS 2013a).

The effects of detrimental water quality have been minimized through implementation of recommendations from ongoing scientific research, which clarifies the relationship of these factors with sucker mortality—Upper Klamath Lake Recovery Unit (USFWS 2013a).

Delisting Criteria:
To safely delist the shortnose sucker, the following additional criteria must be met:

The states of Oregon and California and the Klamath Tribes, collaboratively or separately, should prepare and finalize population management plan(s) for the species (USFWS 2013a).

After 25 years, the average annual rate of population change is greater than one, and the number of spawning individuals is greater than what was present in the baseline years for the Upper Klamath Lake River and Upper Klamath Lake Spring Management Units. Twenty-five years equates to approximately three average adult lifespans for shortnose sucker, and will enable assessment of the populations' response to cyclical threats, such as periodic die-offs and drought. Because it is the first year in which estimates of this type are statistically valid, 2001 will serve as the baseline year for shortnose sucker (USFWS 2013a).

Recovery Actions:
- Restore or enhance spawning and nursery habitat (USFWS 2013a).
- Reduce negative impacts of poor water quality where necessary (USFWS 2013a).
- Clarify and reduce the effects of introduced species on all life stages by conducting and applying scientific investigations (USFWS 2013a).
- Reduce the loss of individuals to entrainment (USFWS 2013a).
- Establish a redundancy and resiliency enhancement program (USFWS 2013a).
- Increase juvenile survival and recruitment to spawning populations (USFWS 2013a).
- Maintain and increase the number of recurring, successful spawning populations (USFWS 2013a).
- Establish a Klamath Basin Sucker Recovery Program (USFWS 2013a).
- Given the cultural importance of these species to The Klamath Tribes, the relationship between this species and the local economy, and the number of state and federal agencies involved in recovery, it is essential to efficiently implement recovery actions through coordination. The final Revised Recovery Plan for this species calls for the establishment of a Recovery Implementation Program to formalize this collaboration and ensure comprehensive stakeholder participation (USFWS 2013b).
- Establishment of Recovery Implementation Team. The revised recovery plan for the Lost River and Shortnose sucker identifies several actions that will promote recovery of this species. Among these is the establishment of a Recovery Implementation Team to coordinate and assess implementation of the plan. This is a very important step to ensure success of the plan (USFWS 2013b).
- Improving Recruitment. The most critical need for this species is to restore natural rates of recruitment to Upper Klamath Lake. Research is needed to clarify how adverse water quality (including algal toxins), entrainment, and habitat availability affect this lack of recruitment (USFWS 2013b).
- Auxiliary Populations. Given that shortnose suckers are steadily declining in the only three populations with any appreciable reproduction, the final Revised Recovery Plan calls for the establishment of auxiliary populations within the natural range of the species to guard against short-term extinction risks. This includes the reestablishment of spawning populations in the Upper Klamath Lake tributaries and springs (USFWS 2013b).
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Conservation Measures and Best Management Practices:

- For most fish species, it is often only possible to generate estimates of the number of adults because of challenges in capturing smaller life stages. In the long-term, the growth rate patterns in the adults will reflect the dynamics of all life stages. Furthermore, adults typically comprise the most stable, long-term component of the population, and therefore, here we generally consider population needs as they affect adults. Annual changes in adult population size reflect two primary demographic forces: survival and recruitment. For long-term demographic stability, recruitment must be sufficiently large to offset losses from mortality. Under pre-disturbance conditions, the long lifespan and high adult survival of Lost River and shortnose sucker life history would offset their low annual recruitment. Therefore, in very general terms, populations of these species need conditions that permit high adult survival and successful spawning and rearing of enough individuals to offset average adult mortality. (USFWS, 2019)
- Climatic trends, resulting from both anthropogenic causes and natural variation, also play an important role. Since 1981, six of the ten lowest inflows into Upper Klamath Lake occurred after 20012 . Upper Klamath Lake, Clear Lake Reservoir and Gerber Reservoir are reservoirs that supply irrigation water for agricultural purposes. Lake levels respond strongly to drought, because each lake is relatively shallow, and because during droughts irrigation water usage is typically increased to offset lower than normal soil moisture in agricultural fields. Lake levels in Clear Lake Reservoir are even more sensitive to droughts given the limited local precipitation and broad, shallow bathymetry of the lake itself. The lake is a shallow water body with a large surface area, which generates high evaporation rates. Drought exacerbates conditions because the volume to surface area relationship skews even more. Severe or prolonged droughts likely negatively affect all sucker life stages throughout their range. (USFWS, 2019)
- Klamath Basin Sucker Assisted Rearing Program One way to improve recruitment in the face of complete early life mortality is through an assisted rearing program. As discussed in Chapter 3, an assisted rearing program was initiated in 2015 with the dual goals of offsetting the harm and harassment of age 0 suckers during the operation of the Bureau of Reclamation's Klamath Irrigation Project and improving the status of SNS in Upper Klamath Lake population through successful recruitment. At present, this effort targets the release of 3,500 subadults (i.e., juveniles between 1 – 4 years old) per year that were collected as larvae from the Williamson River. The first release, which is likely to be substantially smaller than the target, occurred in spring 2018. The current program rears larvae of both endangered SNS and LRS, as identification during early life-stages is problematic. As identification methods become available, efforts will increasingly target SNS. The scale of the Klamath Basin Sucker Assisted Rearing Program is likely to be adjusted in the future to meet recovery goals for both species. Therefore, we present projections for Upper Klamath Lake sucker populations with the addition of varying numbers of individuals for varying durations. The full details of the modeling and the statistical methods are detailed elsewhere (Rasmussen and Childress 2018, entire); however, two assumptions are important for interpretation of the results presented here. First, annual survival in the future was assumed to remain similar to what was been observed in the years 2002-2015. Second, stocked individuals were assumed to enter the population at age 4 and survive at the same rates as adults. This second assumption was necessary because no information on early life survival or the survival of reared individuals in Upper Klamath Lake was available. However, this assumption means that actual production of stocked individuals would need to be higher than the nominal rates presented here to achieve the same results. Higher production would be necessary to offset mortality prior to reaching age 4. (USFWS, 2019)
- RECOMMENDATIONS FOR FUTURE ACTIONS Expand and Improve the Rearing Program The rearing program provides the best short-term avenue to increase the number of shortnose sucker in Upper

Klamath Lake. This effort was identified as a priority Recovery Action (Action # 5) in the revised Recovery Plan (USFWS 2013a). Actions should focus on improving the survival and growth of individuals while in captivity, maximizing survival and recruitment once reintroduced into Upper Klamath Lake, and increasing the overall numbers of individuals stocked. Phosphorus Reduction Poor water quality conditions in Upper Klamath Lake appear to be the most likely driver of persistent recruitment failures in the system. The principal driving factor of the water quality dynamics is the influx of phosphorus into the lake. Specific plans should be developed and actions implemented to secure long-term reduction of phosphorus levels in the system (Recovery Action #2). Adaptive Management The most critical need for this species is to restore natural rates of recruitment to all populations. However, the complexity of biological and physical systems makes it very difficult to determine how to achieve this goal. Adaptive management should be used to implement recovery efforts (including the priorities named above) to ensure the most effective progress towards recovery (Recovery Action #8). Adaptive management includes a cycle of deciding on priority actions, action design, implementation, appropriate monitoring, evaluation, and adjustment of priorities and designs as necessary (USFWS, 2019a)

- Recovery Criteria The recovery criteria comprise a combination of measures that must occur to ameliorate or eliminate threats to the species for each recovery units to achieve numerical demographic targets. These are found in detail in the Revised Recovery Plan (USFWS 2013a). In order to downlist shortnose sucker to threatened status, the following must be achieved: A.1 Current spawning and rearing habitat is maintained and improved access ensures annual use. A.2 A range-wide Spawning and Rearing Enhancement Plan has been developed and implemented. This plan shall identify and prioritize areas of potential spawning and rearing habitat for enhancement and/or restoration, including areas, which are degraded or unavailable due to lack of connectivity or passage. A.3 Connectivity and access is assured to habitats that provide refuge to suckers to avoid poor water quality (particularly Pelican Bay) during the months of July, August, and September – Upper Klamath Lake Recovery Unit. A.4 Natural vegetated wetland areas are restored, including in-stream, wetland, and riparian areas around the mouth of Willow Creek where it meets Clear Lake Reservoir and throughout its drainage – Clear Lake Reservoir Management Unit. C.1 Newly identified or clarified effects of predation and disease are minimized through implementation of recommendations from ongoing scientific research which clarifies the interaction of Lost River sucker and shortnose sucker with predators and pathogens. E.1 An Entrainment Reduction Plan has been developed and implemented. This plan shall identify and prioritize screening of diversions throughout upper Klamath Basin, including the Klamath Project, and propose strategies for efficient reduction of entrainment. E.2 (This action only applies to the Lost River sucker and so is omitted here). E.3 Development and implementation of a plan to assess, monitor, and improve juvenile and sub-adult vital rates and demography, including threats and negative impact reduction. This plan shall also designate specific demographic or vital rate targets, and strategies for achieving these targets, important for downlisting and delisting. E.4 The effects of detrimental water quality have been minimized through implementation of recommendations from ongoing scientific research, which clarifies the relationship of these factors with sucker mortality – Upper Klamath Lake Recovery Unit. In order to delist shortnose sucker the following additional criteria must be met: B.1 The States of Oregon and California and the Klamath Tribes, collaboratively or separately, should prepare and finalize population management plan(s) for the shortnose sucker. E.5 After 25 years, the average annual rate of population change is greater than one and the number of spawning individuals is greater than what was present in the baseline years for the Upper Klamath Lake River and Upper Klamath Lake Spring Management Units. See Appendix II in the Revised Recovery Plan for descriptions and estimation procedures of these measures. Twenty-five years equates to approximately three average adult life spans for shortnose sucker. This period will enable assessment of the species’ response to cyclical threats, such as periodic die-offs and drought. The baseline years for shortnose sucker is 2001, since this is the first year in which estimates of this type are statistically valid for the species. Of these criteria, only criterion A.3 has been realized. This is accomplished through the 2019 Biological Opinion on the operation of the Klamath Project, which provides guidance to the Bureau of Reclamation that ensures access to areas in Upper Klamath Lake, such as Pelican Bay, under normal operating conditions. Nevertheless, this requires regular reevaluation as conditions and operations change. (USFWS, 2019a)

Additional Threshold Information:

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SPECIES ACCOUNT: *Chasmistes cujus* (Cui-ui)

Species Taxonomic and Listing Information

Listing Status: Endangered; March 11, 1967 (32 FR 4001).

Physical Description

Cui-ui (Chasmistes cujus) is a large sucker fish with a long, broad, and deep head. The back of its coarsely-scaled body is blackish-brown with a bluish-gray cast that fades to a creamy-white belly. Cui-ui is probably the largest of the living species of Chasmistes, weighing up to 3.5 kilograms (7.72 pounds). Female cui-ui have been documented exceeding a length of 70 centimeters (cm) (27.6 inches [in.]), with males attaining 66.2 cm (26.1 in.) (USFWS 1992).

Taxonomy

Cui-ui (pronounced kwee-wee) was first described by Edward Cope in 1883 (Cope 1883), and its taxonomic status has not changed. Lakesuckers (genus Chasmistes) are differentiated from other members of the family Catostomidae by thin lips, and by a large terminal, oblique mouth. The four recognized species are residents of three distinct drainage basins: cui-ui in the Truckee River basin of western Nevada (Pyramid Lake); shortnose sucker (C. brevirostris) in the Klamath River basin of Oregon and California; June sucker (C. liorus) in Utah Lake; and the recently extinct Snake River sucker (C. muriei) of the upper Snake River in Wyoming (USFWS 1992). Buth et al. (1992) investigated suspected hybridization, based on morphology, of cui-ui and the Tahoe sucker (Catostomus tahoensis). They found that they were diagnostically different for 20 genetic characters, and there was no genetic evidence of hybridization (Buth et al. 1992).

Historical Range

Cui-ui fossils are known only from the Lahontan Basin where it occupied ancient Lake Lahontan, which covered much of northwestern and west-central Nevada during the Pleistocene era and until 5,000 to 10,000 years ago. Lake levels declined as the climate changed until only fragmented, remnant waters of Pyramid, Winnemucca, Walker, and Honey lakes remained. At the beginning of the twentieth century, cui-ui inhabited Pyramid Lake and Winnemucca lakes. The species was eliminated from Winnemucca Lake when it dried in the 1930s following unrestricted diversion of water from the Truckee River and a severe drought (USFWS 1992).

Current Range

The cui-ui is now restricted to Pyramid Lake and the lower Truckee River (downstream from Derby Dam) (USFWS 1992).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: The cui-ui [kwee-wee] is an opportunistic invertivore/planktivore, feeding on zooplankton, phytoplankton, and invertebrates such as small crustaceans and insect larvae or pupae. It feeds mainly in shallow to medium-depth water 10 to 30 m (30 to 100 ft.) deep, although it has been observed to feed in schools near the surface over deeper waters. It has a slow growth rate, with no known competitors or dependencies for feeding (USFWS 1992; Sigler et al. 1985; NatureServe, 2015).

Reproduction Narrative

Adult: The cui-ui is an obligate, fresh water spawner. Cui-ui become capable of reproductive activity between the ages of 6 and 12 years. Reproduction occurs once a year, and cui-ui are capable of spawning annually. However, reduced fresh water inflows and passage barriers to the Truckee River have apparently precluded spawning in some years. Surges of fresh water in the spring apparently trigger spawning activities. Sufficient flows to access the river are needed, with water depths of 9 to 43 cm (3.5 to 17 in.). Spawning starts in April to May, depending on timing of runoff, river access, and water temperatures, and lasts about 1 month. Females broadcast eggs over an average of 50 m2 (538 sq. ft.) of predominantly gravel substrate in water depths of 0.24 to 1.22 m (0.8 to 4.0 ft.), often at the head of gravel bars in the lower Truckee River. The males fertilize the eggs by positioning themselves beside the female as she deposits her eggs. Individuals complete spawning over a 3- to 7-day period. Due to their long life span of up to 40 years, and the up to 55,000 eggs deposited annually, the cui-ui has a high reproductive capacity. Once the eggs hatch, the juveniles remain in fresh water for about a week, then move downstream into the lake waters. The majority of spawning occurs in the lower Truckee River; however, there have been several reports of cui-ui spawning in Pyramid Lake at the fresh water-lake saline interface near springs on the southwestern shore (USFWS 1992; Sigler et al. 1985).

Geographic or Habitat Restraints or Barriers

Adult: Restricted to Pyramid Lake and the lower Truckee River below Derby Dam* Note: Depending on flow conditions, limited habitat may also be available for spawning below Marble Bluff Dam in some years, and above Numana Dam in some years. Suggest just keeping it simple and say that habitat below Derby Dam may be available depending on flow conditions in a particular year.

Spatial Arrangements of the Population

Adult: Stratified; for much of the year adult and juvenile cui-ui inhabit the littoral zone at depths of 18 to 31 m (60 to 100 ft.). Juveniles appear to concentrate at the northern and southern ends of the lake. They are most active during summer and fall; however, a seasonal migration pattern has not been demonstrated (USFWS 1992).

Environmental Specificity

Adult: Community with key requirements common.

Tolerance Ranges/Thresholds

Adult: Moderate

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: Unknown

Habitat Narrative

Adult: The cui-ui is now restricted to Pyramid Lake and the lower Truckee River (downstream from Derby Dam). The elevation of Pyramid Lake is nearly 24 m (80 ft.) lower than at the turn of the century; the water is saline and alkaline, ranging from oligotrophic to mesotrophic, depending on fresh water inputs. Adult and juvenile cui-ui inhabit Pyramid Lake year-round in the littoral zone at depths of 18 to 31 m (60 to 100 ft.). Juveniles appear to concentrate at the northern and southern ends of the lake. They are most active during summer and fall; however, a seasonal migration pattern has not been demonstrated. There are structural barriers (e.g., Marble Bluff and Numana dams) to fish passage up the Truckee River. Adults use the lower 19 km (12 mi.) of the Truckee River only during the spawning season (ranging from as early as April to as late as June), and only in years in which there is sufficient attraction flow and passage above or around the delta that forms at the mouth of the Truckee River. Most spawners use the 16-km (10-mi.) reach between Marble Bluff and Numana dams; the fish ladder at Numana Dam does not allow passage of cui-ui (USFWS 1992; Sigler et al. 1985; NatureServe 2015).Essential habitat is the portion of the Truckee River basin that provides spawning and rearing habitat for cui-ui and which has the greatest impact on physical, chemical and biological components of cui-ui spawning and rearing habitat. Essential habitat for cui-ui is determined to be the Truckee River from Hunter Creek (western Reno) to and including Pyramid Lake and its tributaries (USFWS 1992). This designation is substantiated by the following:- the majority of point and nonpoint sources for pollutants in the Truckee River occurs from Reno downstream (USFWS 1992);- the greatest volume of water is diverted from the river (numerous sources) from Reno downstream (USFWS 1992);- the majority of habitat alteration in the river has occurred from Reno downstream (USFWS 1992); and- there are reports (unconfirmed) of cui-ui spawning in the river as far upstream as Lockwood (east of Reno) (USFWS 1992).

Dispersal/Migration

Motility/Mobility

Adult: High

Migratory vs Non-migratory vs Seasonal Movements

Adult: Possible seasonal movements in Pyramid Lake and movement to the Truckee River to spawn in the spring, then return to the lake. Passage barriers restrict movement up the Truckee River beyond Numana Dam (USFWS 1992; Sigler et al. 1985). Note: FWS is working with partners to redesign the Numana Dam to provide improved fish passage. the new design will allow cui-ui regular access to spawning habitat above Numana Dam.

Dispersal

Adult: Low

Immigration/Emigration

Adult: Unlikely

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: The cui-ui do not migrate outside their restricted range. Cui-ui move into the Truckee River to spawn in the spring, then return to the lake after spawning. Passage barriers restrict movement up the Truckee River beyond Numana Dam. Possible seasonal movements in Pyramid Lake have been noted but not confirmed. All historic habitat outside of Pyramid Lake is now dry due to water diversions (USFWS 1992; Sigler et al. 1985).

Additional Life History Information

Adult: Historically occupied habitat, such as Winnemucca Lake, has dried up due to water diversions. Low Truckee River flows/inflows to Pyramid Lake in dry climatic years may prevent or severely limit spawning migrations.

Population Information and Trends

Population Growth Rate:

Slow

Number of Populations:

One

Population Size:

The population was estimated at 300,000 adults and several million juveniles in 1992 (USFWS 1992). The population is currently estimated to be between 100,000 and 1,000,000 individuals. In the early 2000s, spawning runs were low or nil, following a run of 585,000 in 1999. Then high flows stimulated a run of over one million in 2005 and approximately 900,000 in 2011.

Adaptability:

Low

Additional Population-level Information:

Population size is highly dependent on reproductive success, which is dependent on water levels and flow for spawning.

Population Narrative:

Populations have been slowly increasing, but are highly dependent on water levels and inflows for successful spawning and reproduction (USFWS 1992; NatureServe 2015). The population is currently estimated to be between 100,000 and 1,000,000 individuals (NatureServe 2015).

Threats and Stressors

Stressor: Alterations to spawning habitat from reduced water flows due to water diversion, river channelization due to development and agriculture, reduced riparian canopy due to agriculture and timber harvesting, and increased bank erosion.
Exposure: Cui-ui attempting to move into the Truckee River to spawn.
Response: Reduced survival egg viability and hatching.
Consequence: Decreased reproductive success; reduction in population.
Narrative: Upstream diversion and storage of water has significantly altered and reduced fresh water flows into Pyramid Lake, altering water quality. River channelization, agriculture, and

timber harvesting have contributed to reduced riparian canopy; this reduces shade, thereby increasing water temperatures. Reduce riparian vegetation results in increasing bank erosion (USFWS 1992; Sigler et al. 1985; NatureServe 2015).

Stressor: Reduced fresh water inflows to lake habitat, resulting in increasing Total Dissolved Solids (TDS) and lowering lake levels.
Exposure: Prolonged periods of drought and reduced flows from diversions, resulting in reduced flows and increased TDS.
Response: Reduced growth, illness.
Consequence: Reduction in population numbers.
Narrative: Upstream diversion and storage of water has significantly altered and reduced fresh water flows into Pyramid Lake, increasing TDS as the volume of the water in the lake decreases, and reducing water quality (USFWS 1992; Sigler et al. 1985; NatureServe 2015).

Stressor: Habitat alteration from siltation and/or pollution from point and nonpoint sources.
Exposure: Exposure to high silt and/or pollution concentrations in the water column.
Response: Reduced growth; illness.
Consequence: Reduced habitat quality and population numbers.
Narrative: Pollutants and/or silt from point and nonpoint sources enter the entire Truckee River from municipal, agricultural, and industrial sources, resulting in high levels of nutrient loading to the river and Pyramid Lake. Increased sediment loads, decreased dissolved oxygen, and other parameters reduce habitat quality for cui-ui (USFWS 1992; Sigler et al. 1985; NatureServe 2015).

Stressor: Increased water temperatures due to lower lake water volume and depth, and climate change.
Exposure: Movement into shallower, warmer waters to feed; or into spawning habitat with inadequate flows and riparian shade.
Response: Reduced growth; illness.
Consequence: Reduction in population numbers; decreased reproductive success.
Narrative: Prolonged drought and reduced inflows lower the lake level, resulting in depths and volumes of water insufficient to maintain colder temperatures. Climate change may also contribute to increasing water temperatures. Increased water temperatures can reduce reproductive success and contribute to disease and illness, thereby reducing population numbers (USFWS 1992; Sigler et al. 1985; NatureServe 2015).

Stressor: Increased water flows (rapid melting of snow) due to cllimate change; climate change causes flash flood events and Cui-ui cannot swim in current successfully during high flow times
Exposure: Cui-ui attempting to move into the Truckee River to spawn.
Response: Reduced reproduction potential
Consequence: Reduced spawning
Narrative:

Stressor: Threat of invasive plants and invertebrates (zebra and quagga)
Exposure: food web
Response: Reduced habitat and food availability
Consequence: Reduced habitat quality and population numbers.
Narrative:

Stressor: Increased nutrient loading that limits larvae survival (high TDS, nitrogen, phosphorus) exposures primarily from sewage treatment plant effluent waste released into Truckee River
Exposure: Reduced growth, illness, parasite susceptibility
Response: Reduced growth, illness. Lack of larvae survival
Consequence:
Narrative:

Stressor: Increased exposure to contaminants (aside from pesticides) such as fuels (run-off boat/jetski), sunscreen, Pharmaecutically active compounds (in effluent discharge) etc.
Exposure: Reproductive harm, reduced growth, illness, parasite susceptibility, ulcers (growths)
Response:
Consequence:
Narrative:

Stressor: Increasing algal blooms and severity of bloom due to increased water temperatures (and nutrient loading). Blooms can significantly reduce dissolved oxygen levels.
Exposure: Reproductive harm, reduced growth, illness, parasite susceptibility, ulcers (growths). Lethal
Response: Reduced survival, illness
Consequence:
Narrative:

Stressor: Changes to water quality and quantity resulting from increased fire size and severity in the Tahoe/Truckee basins resulting from climate change and fuel loads; alteration to lake ecology from wildlife smoke
Exposure: Potential exposure to changes in water quality and quantity, e.g., changes in primary production, zooplankton biomass, community composition, light/temperature
Response: Reduced survival, illness, reproductive harm, reduced habitat, potential changes in food availability
Consequence:
Narrative:

Recovery

Reclassification Criteria:
The species has a probability of at least 0.85 of persisting for 200 years;

Additional annual Truckee River inflow to Pyramid Lake of 45,000 acre-feet or the equivalent benefit have been secured at a minimum rate of 5,000 acre-feet/year; and

Estimated numbers of adult cui-ui and year classes of juveniles and adults has been stable or increasing during the previous 15 years (USFWS 1992).

Delisting Criteria:
The species has a probability of at least 0.95 of persisting for 200 years;

Additional annual Truckee River inflow to Pyramid Lake of 65,000 acre-feet or the equivalent benefit beyond the amount required for reclassification (equivalent to 110,000 acre-feet) has been secured at a minimum rate of 5,000 acre-feet/year;

Estimated numbers of adult cui-ui and year classes of juveniles and adults have been stable or increasing during the previous 15 years;

Lake and river water quality standards have been achieved during the previous 15 years;

The lower Truckee River floodplain has been rehabilitated;

Marble Bluff Fish Facility and Numana Dam Fish Ladder have been modified to pass upstream at least 300,000 adult cui-ui during a spawning run;

Maintenance and operation of various water storage and fish passage facilities for cui-ui have been secured; and

A hatchery refuge for brood stock has been established to protect against catastrophic events (USFWS 1992).

Recovery Actions:

- The 1983 revision to the Recovery Plan changed the recovery goal and strategy. The goal became delisting of cui-ui to nonendangered status by restoring and maintaining an optimum, self-sustaining population in the Truckee River-Pyramid Lake system. The recovery goal was not quantified because little was known of cui-ui life history and habitat. The three main points are:
- Identification, rehabilitation, and maintenance of sufficient habitat for cui-ui in the Truckee River and Pyramid Lake to maintain the optimum population through natural reproduction;
- Protection and management of the optimum self-sustaining cui-ui population; and
- Education of the public about the recovery effort. Emphasis continued to be placed on identification and rehabilitation of habitat and proper management of the population.
- Securing spawning habitat in the lower Truckee River and rearing habitat in Pyramid Lake by improvements in watershed management, including timing of storage releases and efficient water use. Increase volume and improve timing of inflow; rehabilitate the lower river; achieve water quality standards; and improve fish passage in the lower Truckee River.
- Continued research on cui-ui population dynamics, life history, and habitat to further characterize life stage requirements and identify water quality limitations.
- Operate cui-ui hatchery.
- No translocation outside their historic range, per Service policy. Recovery cannot be achieved by introducing cui-ui into another river-lake system. There is no system within the species' historical range that provides spawning and rearing habitat similar to that of Truckee River-Pyramid Lake.
- Use computer models to determine the efficacy of various water quality management scenarios to meet water quality standards in the Truckee River.
- Update and revise recovery plan and objectives as tasks are completed, or revised as conditions in the basin change and as additional information becomes available.

Conservation Measures and Best Management Practices:

- Securing and improving spawning habitat in (and water for) the lower Truckee River, access to spawning habitat, and rearing habitat in Pyramid Lake through by improvements in watershed management, including timing/amount of available storage releases and efficient water use for projects that divert large amounts of Truckee River water on an annual basis. In particular, increase the efficiency of Newlands Project water deliveries by lining earthen canals, thus decreasing the need to divert Truckee water to meet Lahontan Reservoir storage targets and deliveries to irrigators. Increase volume and improve timing of inflow to Pyramid Lake; rehabilitate the lower river (e.g., riparian restoration, improving channel sinuosity, stabilizing the river channel); achieve water quality standards; and improve fish passage in the lower Truckee River.
- Continued research on cui-ui population dynamics, life history, and habitat to further characterize life stage requirements and identify water quantity and water quality limitations.
- Operate cui-ui hatchery.
- No translocation outside their historic range, per Service policy. Recovery cannot be achieved by introducing cui-ui into another river-lake system. There is no system within the species' historical range that provides spawning and rearing habitat similar to that of Truckee River-Pyramid Lake.
- Use computer models to determine the efficacy of various water quality management scenarios to meet water quality standards in the Truckee River.
- Update and revise recovery plan and objectives as tasks are completed, or revised as conditions in the basin change and as additional information becomes available.

Additional Threshold Information:

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SPECIES ACCOUNT: *Chasmistes liorus* (June sucker)

Species Taxonomic and Listing Information

Listing Status: Reclassified to threatened Feb 3, 2021.

Physical Description

A fish (sucker) with a large, oblique, terminal mouth; total length up to 52 cm. Lakesuckers (genus Chasmistes) are mid-water planktivores, which are differentiated from other members of the family Catostomidae by their thin, separated lips that may lack papillae, branched dendritic gill rakers, and large, terminal, obliquely positioned mouths. (USFWS, 1999; NatureServe, 2015)

Taxonomy

Original population in Utah Lake may be extinct. When numbers were low, C. liorus hybridized with Catostomus ardens, which apparently led to introgression of new characters into the population; now this form (described as a new subspecies, C. l. mictus), is abundant, according to Miller and Smith (1981). Ongoing research may reveal if any unhybridized C. liorus remain. Catostomus fecundus is an invalid taxon because it was based on hybrids between C. ardens and C. liorus. Chasmistes and Deltistes are closely related to the older, more diverse, widespread genus Catostomus; Chasmistes species are distinctive in having branched gill rakers and a terminal mouth (Scoppettone and Vinyard 1991). (NatureServe, 2015)

Current Range

Native range includes Utah Lake (380 square kilometers) and the adjacent Provo River, Utah. Refuge populations of the June sucker have been established in protected locations throughout Utah. One reported specimen, collected from the Snake River below Jackson Lake Dam, Wyoming, represents another species, C. muriei, which is now presumably extinct (Miller and Smith 1981). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 3/31/1986.

Legal Description

On March 31, 1986 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Chasmistes liorus (June sucker) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Utah (51 FR 10851-10857).

The critical habitat designation for Chasmistes liorus includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Chasmistes liorus.

Critical Habitat Designation

The critical habitat designation for Chasmistes liorus includes one CHU in Utah County, Utah (51 FR 10851-10857).

Utah, Utah County. Provo River, Sec. 5, T7S R2E to Sec. 36, T6S. R2E, the lower 7.8 kilometers (4.9 miles) of the main channel of the river as measured from it confluence with Utah Lake, upstream to the Tanner Race diversion.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (51 FR 10851-10857):

(1) One to three feet of high quality water constantly flowing over a clean, untsilted gravel substrate.

(2) Larval June suckers require shallow areas with low velocities connected to the main channel of the river.

Special Management Considerations or Protections

While the June sucker is found throughout Utah Lake, this area is vital to its reproduction and requires special management considerations. In the future, however, suitable habitat in Utah Lake and additional sections of the Provo River could be proposed as critical habitat if it is found to be essential to the conservation of the species.

Life History

Feeding Narrative

Larvae: Both larval and juvenile June sucker fed on planktonic prey. (USFWS, 1999)

Juvenile: Both larval and juvenile June sucker fed on planktonic prey. (USFWS, 1999)

Adult: Research on other Chasmistes, and the morphological adaptations of the June sucker, indicate that the species is a mid-water planktivore (Millerand Smith 1981; Scoppettone et al. 1986; T. Crowl, USU, Pers. Comm.). Both larval and juvenile June sucker fed on planktonic prey. Target size selection included continuously larger prey items being consumed with increasing fish size. Scoppettone et al. (1986) observed that the diet of adult cui-ui in Pyramid lake was almost exclusively composed of zooplankton. Similarly, Modde and Muirhead (1990) found that growing June sucker continued feeding on zooplankton following metamorphosis to the adult form. Since these stocking activities have begun, nine marked fish have been recaptured. Two of these, captured in 1997, exhibited growth rates in the lake averaging 0.2075 mm/day and 0.8015 g/day, suggesting at least partial success of these stocking efforts. (USFWS, 1999)

Reproduction Narrative

Adult: Most spawning is completed within a span of five to eight days. Spawns mainly in June, at water temperatures of 12-13 C; activity greatest at midday (1100-1400 h). Eggs hatch in 4 days at about 21 C. Larvae enter the water column about 10 days after hatching (Sigler and Sigler 1987). In 1987-1988, spawned over a two-week period in early June; emergent larvae emigrated from the river over a two- to three-week period; peak emergence of larvae occurred in late June

(Modde and Muirhead 1994). Otolith analysis suggests that sexual maturity may be attained as early as age 5 but at least by age 10 (Belk 1998). Life span may exceed forty years (Scoppettone and Vinyard 1991). Assuming that decreased growth rate indicates probable maturation, June sucker may mature as early as age five, but at least by age ten (Belk 1998). June sucker eggs are pale yellow, demersal, and weakly adhesive. Larval development and hatching periods have been describedby Shirley (1983) and Snyder and Muth (1988). Shirley (1983) indicated that June sucker eggs hatched in four days at 21. 10C (700F) and in ten days at 10.6 C (51.1 F). Water velocities where June sucker spawning occurs averages approximately 37 cm/s (1.21 ft/s) and ranges from 6 cm/s to 98 cm/s (0.20 ft/s to 3.2 ft/s) (Radant et al. 1987). Water depth at spawning sites typically ranges from 30 cm to 86 cm (11.8 to 33.9 in) with a mean of 51 cm (20.0 in) (Shirley 1983). Mean river temperatures during spawning ranges from 11 to 15 C (52 to 60 F) (Radant and Sakaguchi 1981; Gutermuth and Lentsch 1993). Egg development time, measured in the river as the period between peak egg drift and peak larval drift (incubation plus time to full yolk absorption), was 19 days in 1987 (12 to 16 C; 53.6 to 60.8 F) and 9 days in 1988 (15 to 19 C; 59 to 66.2 F). In the laboratory, larvae remained quiescent on the bottom for ten days after hatching at 10.6 C (51.1 F) (Shirley 1983). At 17 C (62.6 F), larvae swam up in seven to eight days post-hatch (Gutermuth and Lentsch 1993). (USFWS, 1999; NatureServe, 2015)

Habitat Narrative

Adult: This sucker inhabits Utah Lake and tributaries, in Utah. Probably it formerly occurred throughout the lake, but now it may occur mainly in shallower, more protected areas (Sigler and Sigler 1987). Utah Lake is shallow (maximum depth 4.3 m, average depth 2.7 m), turbid, and slightly saline (Matthews and Moseley 1990). Spawning occurs in large tributary streams (lower portion of Provo River and, at least formerly, lower Spanish Fork River), in shallower riffles over coarse gravel and cobble; water depth at spawning sites is 30-76 cm, water velocity 6-137 cm/sec. Newly hatched larvae remain on the bottom for several days, move downstream immediately after swim-up (Scoppettone and Vinyard 1991). (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: Moderate (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Migratory (NatureServe, 2015)

Dispersal

Adult: Moderate (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Migrates upstream to spawning habitat in spring (typically in June). Water diversion barrier limits upstream migration to about 8 km (Matthews and Moseley 1990). (NatureServe, 2015)

Population Information and Trends

Population Trends:

Approximately 3,500 June suckers were spawning annually in Utah Lake tributaries as of 2016 (Conner and Landom 2018, p. 2). This represents at least a ten-fold increase in spawning fish from when the recovery plan was finalized in 1999 (USFWS, 2021)

Species Trends:

Increasing (USFWS, 2021)

Number of Populations:

1 (NatureServe, 2015)

Population Size:

likely >3,500 (USFWS, 2021)

Population Narrative:

Population declined from millions in the early 1800s to fewer than 1,000 wild-spawned adults today (June Sucker Recovery Implementation Program, http://www.junesuckerrecovery.org/). USFWS (1990) categorized the status as "declining." Decline of >90% As of late 1980s, the adult population was believed to number about 1,000, apparently all of them over 15 years of age, with little or no recruitment (Matthews and Moseley 1990), due to high populations of non-native predatory fishes (USFWS 1990). In the late 1990s, wild adult population may have been close to 300 individuals (Keleher et al. 1998; C. Keleher, in Belk 1998). Most suckers captured during spawning runs in recent years have been captive-reared individuals. This species is represented by one occurrence (subpopulation). (NatureServe, 2015). Due to the immediate threat of June sucker extinction at the time of listing, the UDWR began raising populations in hatcheries and at secure refuge sites. These efforts resulted in the stocking of June suckers into Utah Lake to boost population numbers beginning in the 1990s and continuing through the present day (UDWR 2018b, p. 3). As of 2017, more than 800,000 captive-bred June suckers have been stocked in Utah Lake (UDWR 2017b, p. 6). Stocking is planned to continue until the wild population is self-sustaining, which will be determined by population viability analysis (JSRIP 2018, p. 10). Approximately 3,500 June suckers were spawning annually in Utah Lake tributaries as of 2016 (Conner and Landom 2018, p. 2). This represents at least a ten-fold increase in spawning fish from when the recovery plan was finalized in 1999 (Conner and Landom 2018, p. 2). The vast majority of fish detected spawning in Utah Lake tributaries are stocked fish that have become naturalized (survived for multiple years until reaching breeding age) (UDWR 2018c, p. 7). For all spawning tributaries combined, the spawning population size for both sexes substantially increased from 2008 to 2016, and the total known spawning population size grew by 22 percent. These figures represent a minimum number of confirmed spawning June suckers, not a population estimate. They do not include subadult or juvenile individuals, non-spawning adults, untagged fish, or tagged fish that were not detected via the monitoring antennae. (USFWS, 2021)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 1999)
Exposure:
Response:
Consequence:

Narrative: Habitat alterations include the following: (1) water development has altered natural flow events, reduced annual lake-level stability, and blockedmigration corridors; (2) changes in water quality have resultedin higher monthly river and lake temperatures, reduceddissolved oxygen levels, increased sedimentation rates and levelsofdissolved solids, and increased turbidity; and (3) urbanization has resulted in development of the Provo River flood plain, channelization of the river and a reduction in available nursery habitat (USFWS, 1999).

Stressor: Loss of recruitment (USFWS, 1999)
Exposure:
Response:
Consequence:
Narrative: The combination of altered flow regimes, water extraction,turbidity increases from run-off and the introduction of carp hasresulted in Utah Lake becoming a relatively homogeneous lake ecosystem. The loss of aquatic vegetation due to the above activities has led to an almost complete loss of refugia habitats for small suckers which makes them highly susceptible to fish predation. In addition, the channelization and fragmentation of the Provo River has resultedin very little nursery habitat for juvenile and young June suckers. This results in their immediate transport into Utah Lake which is now void of structural habitat and refugia. These conditions have led to the loss of recruitment of young June suckers (USFWS, 1999).

Stressor: Nonnative fishes (USFWS, 1999)
Exposure:
Response:
Consequence:
Narrative: The introduction of nonnative fishes has resulted in competition and predation as well as water quality changes such as increased turbidity (USFWS, 1999).

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Reclassification Criteria:
1. Provo River flows essential for June sucker spawning and recruitment are protected. (USFWS, 1999)

2. Habitat in the Provo River and Utah Lake has been enhanced and/or established to provide for the continued existence of all life stages. (USFWS, 1999)

3. Non-native species which present a significant threat to the continued existence of June sucker are reduced or eliminated from Utah Lake. (USFWS, 1999)

4. An increasing self-sustaining spawning run of wild June sucker resulting in significant recruitment over ten years has been re-established in the Provo River. (USFWS, 1999)

Delisting Criteria:
1. Establishment of a second self-sustaining, protected, refugia population of June sucker within the Utah Lake Basin. (USFWS, 1999)

2. Establishment of an additional self-sustaining spawning run of June sucker in Utah Lake. This will require adequate protection of instream flows and available habitat, as well as successful recruitment to the spawning run of June sucker naturally produced in the Lake. (USFWS, 1999)

3. Removal of other threats to the continued existence of June sucker including those associated with the required physical, chemical and biological environment of Utah Lake necessary for survival of the species. (USFWS, 1999)

Recovery Actions:
- Conserve genetic integrity of June sucker. (USFWS, 1999)
- Monitor status and trends of June sucker population. (USFWS, 1999)
- Evaluate and minimize factors limiting recruitment of June sucker. (USFWS, 1999)
- Enhance June sucker population in Utah Lake and its tributaries. (USFWS, 1999)
- Develop and conduct Utah Lake ecosystem and June sucker information and education programs. (USFWS, 1999)
- Implement measures to protect the June sucker during its spawning run. (USFWS, 1999)
- Further define criteria necessary for the recovery of the June sucker. (USFWS, 1999)
- Development of brood stock and an interim facility for propagation of June sucker for reintroduction and establishment of refuge populations. (USFWS, 1999)
- Planning for a warm-water fish hatchery within the State of Utah, primarily for June sucker production. (USFWS, 1999)
- Development and maintenance of refuge populations. (USFWS, 1999)
- Enhancement of the June sucker population in Utah Lake. (USFWS, 1999)
- Population monitoring. (USFWS, 1999)
- Acquiring funding for and implementing numerous research projects including evaluating genetics of June sucker in Utah Lake and those being held for broodstock and refuge development, estimating larval drift velocities in the Provo River, larval habitat use studies of the Provo River, early life history characteristics of the June sucker, and use of vegetation mats as cover. (USFWS, 1999)
- Enhancement of spawning and nursery flows in the Provo River to simulate a natural hydrograph. (USFWS, 1999)
- Minimalization of non-native impacts. (USFWS, 1999)
- Construction of a weir in the lower Provo River to facilitate capture of spawning suckers for monitoring and taking of eggs and to restrict non-native fishes from entering the river. (USFWS, 1999)
- Defining the criteria necessary for the recovery of June sucker. (USFWS, 1999)
- Conservation of the genetic integrity of the June sucker. (USFWS, 1999)
- Increased presence of law enforcement and biologists on the Provo River during the spawning run to deter vandals. (USFWS, 1999)

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SPECIES ACCOUNT: *Chrosomus (=Phoxinus) cumberlandensis* (Blackside dace)

Species Taxonomic and Listing Information

Listing Status: Threatened; Southeast Region (R4)(USFWS, 2015)

Physical Description

The blackside dace is characterized by a wide, black lateral stripe or two stripes converging on the caudal peduncle, an olive-colored dorsal surface with numerous dark spots/speckles, and scarlet and yellow coloration on the head and abdomen (most pronounced in the spring). The scales are small and embedded. The lateral line is incomplete, and lateral scales average approximately 75. The species has eight anal rays. During the breeding season, males of the species exhibit an intense black lateral stripe; scarlet coloration on the abdomen, ventral portion of the head, nape, and base of the dorsal fin; bright yellow fins with metallic spots; and a golden dorsum. The blackside dace is similar to the southern redbelly dace but can be distinguished by its single lateral stripe or two convergent stripes (the southern redbelly dace has two parallel stripes) and the shape of its opercular bone (Starnes and Starnes 1978; Etnier and Starnes 1993).

Taxonomy

The blackside dace is a member of the minnow family (Cyprinidae), reaching a maximum length of approximately 3 in (Etnier and Starnes 1993). The species was probably first observed in 1883 by D. S. Jordan and J. Swain in Clear Fork River tributaries in Whitley County, Kentucky, and described based on color; they regarded it as a color variation of the southern redbelly dace (Phoxinus erythrogaster) (Starnes and Starnes 1978). The species was not recognized and described as a distinct species until 1978 (Starnes and Starnes 1978). In a recent phylogenetic analysis of all North American and Eurasian species, Phoxinus phoxinus, Strange and Mayden (2009) found that the genus, as currently recognized, is an unnatural group. To have a classification that is consistent with the monophyletic groups recovered in their phylogeny, they proposed a revised taxonomy that elevates the subgenus Chrosomus to genus rank. Chrosomus includes the blackside dace, among six other North American species currently recognized in the genus Phoxinus (Strange and Mayden 2009).

Historical Range

The blackside dace is thought to have been widely distributed historically in small streams throughout the upper Cumberland River drainage in Kentucky and Tennessee (Figure 2). The first range-wide survey conducted by Starnes (1981) reported the species from only 27 of 168 surveyed streams (16.1 percent). Based on an evaluation of physical habitat compared to the species' preferences, Starnes (1981) speculated that the species had been eliminated from at least 52 streams before its existence was known, approximately 60 to 70 percent or more of its historical range. (NatureServe, 2015)

Current Range

When the recovery plan was completed in 1988, the species was known from a total of 35 streams in Kentucky and Tennessee. Currently, blackside dace populations are estimated to persist in 125 streams across nine Kentucky counties (Bell, Harlan, Knox, Laurel, Letcher, McCreary, Perry, Pulaski, and Whitley), three Tennessee counties (Campbell, Claiborne, and

Scott), and two Virginia counties (Lee and Scott) (Black et al. 2013a; Skelton 2007, 2013; USFWS unpublished data) (Figure 3; Table 7, Appendix C) (USFWS, 2015)

Distinct Population Segments Defined

No (USFWS, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Feeding habits and reproductive characteristics were investigated by Starnes and Starnes (1981), who reported schools of 5 to 20 fish grazing on rocks and sandy substrates. Gut analyses revealed that sand comprised the largest portion of the species' gut (36%). The remaining portions of the gut were composed of unidentified organisms (32%), algae and diatoms (12%) and macroinvertebrates (4.5%). However, during the winter, macroinvertebrates composed the entire diet (Starnes and Starnes 1981).

Reproduction Narrative

Adult: The spawning period for the species extends from April until July (Starnes and Starnes 1981), but spawning individuals have been observed in late March in the Rock Creek basin, a tributary of Jellico Creek in southeastern McCreary County, Kentucky. Eggs are typically deposited in fine gravel, primarily in nests constructed by other species such as creek chubs (Cicerello and Laudermilk 1996) and central stonerollers (Campostoma anomalum) (Starnes and Starnes 1981). Creek chub nests appear to be used more often than stoneroller nests, as suggested by Cicerello and Laudermilk (1996). In a study of blackside dace reproductive behavior, Mattingly and Black (2007) provided evidence that blackside dace rely heavily on creek chubs as a nest-building spawning associate, perhaps in an obligatory fashion. Mattingly and Black (2007) observed 25 spawning events, and all of these events took place over creek chub nests; there was no evidence that blackside dace spawned independently. It is suspected that the species takes advantage of other species' nests because these habitats provide the most abundant silt-free substrates in much of the species' current range. Rakes et al. (2013) were successful in enticing captive blackside dace to spawn without any cues from other nest building fish species. However, it remains unknown whether the species will construct nests independent of other species in natural streams if suitable substrates are available (Mattingly, personal communication, 2006). Starnes (1981) observed spawning in May at water temperatures of approximately 64oF. Females deposited eggs on fine gravel at the lip of an existing stoneroller nest located in a run area. Adults are capable of spawning at age I and have a lifespan of three to four years (Starnes and Starnes 1981); females appear to have greater survivorship (Starnes and Starnes 1981). Starnes and Starnes (1981) reported the sex ratio in September as 21 males-to-29 females and in April as 11 males-to-11 females. Based on length/frequency and scale data, growth rates were similar for males and females (age 0, 20 to 24 milimeters standard length [mm SL]; age I, 39 to 57 mm SL; and age II, 62 to 64 mm SL). The fastest growth occurs during the first year and then gradually declines during the second and third years (Starnes and Starnes 1981). Fish species commonly found in association with blackside dace include the creek chub, central stoneroller, white sucker (Catastomus commersoni), northern hogsucker (Hypentelium nigricans), green sunfish (Lepomis cyanellus), stripetail darter (Etheostoma kennicotti), arrow darter (E. sagitta sagitta), and rainbow darter (E. caeruleum) (Starnes and Starnes 1978; O'Bara 1990; Mattingly et al. 2005). Additional species that may occur along with blackside dace include the bluntnose minnow (Pimephales notatus), silverjaw minnow (Notropis buccata), striped shiner (Luxilus chrysocephalus), longear sunfish (Lepomis megalotis), redbreast sunfish (Lepomis auritus), and Cumberland darter (Etheostoma susanae). Based on published research by Eisenhour and Piller (1997), blackside dace have been shown to successfully hybridize with creek chubs.

Habitat Narrative

Adult: This species inhabits small upland headwaters and creeks 2-5 meters wide where riffle and pool areas are about equal, and substrates are sand, sandstone, and shale (Burr and Warren 1986, Etnier and Starnes 1993). It occurs in pools with cover such as bedrock, rubble, undercut banks, or brush, and generally is associated with lush riparian vegetation, canopy cover greater than 70%, cool water, and unsilted conditions. The species can apparently recolonize areas when water quality or habitat conditions become more favorable if suitable dispersal corridors exist (Strange and Burr 1995). Blackside dace exist as metapopulations (groups of local populations for which dispersal corridors are very important in the persistence of individual local populations) (Strange and Burr 1995).CREEK; Moderate gradient; Pool (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: High

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratoy

Dispersal/Migration Narrative

Adult: Mattingly et al. (2005) and Detar (2004) studied movement patterns of the species by tagging 653 dace from Big Lick Branch (Pulaski County, Kentucky) and Rock Creek (McCreary County, Kentucky) with visible implant elastomer injections. Movement was monitored in Big Lick Branch from November 2002 to August 2005 (post-March 2004 data have not yet been analyzed; data reported below are for an approximate one-year cycle, November 2002 to March 2004) and in Rock Creek from March 2003 to March 2004 using baited minnow traps. The majority of tagged dace (81% in Big Lick Branch and 58% in Rock Creek) were recaptured within their original tagging site. Other individuals moved considerable distances from their original tagging site, including the first documented inter-tributary movement for the species (the tagged individual moved from an unnamed tributary of Big Lick Branch downstream through impounded backwaters of Lake Cumberland and into Big Lick Branch). Distances moved upstream in Big Lick Branch (148 plus or minus [+] 138 m) and Rock Creek (733 + 1,259 m) were not statistically different from distances moved downstream (77 + 29 m and 314 + 617 m, respectively). However, the mean overall distance moved was statistically greater in Rock Creek than in Big Lick Branch; maximum distances moved in Big Lick Branch and Rock Creek were 1.0 kilometers (km) and 4.0 km, respectively (Mattingly et al. 2005; Jones 2005). These results were similar to other movement studies suggest that some stream fish populations are comprised of a relatively large sedentary group and a small mobile group (Freeman 1995; Smithson and Johnston 1999; Rodriguez 2002).

Population Information and Trends

Number of Populations:

27 (USFWS, 2022)

Population Size:

655 total (USFWS, 2022)

Population Narrative:

Research by Mattingly et al. (2005) and Detar (2004) investigated population densities within the species' current range. Blackside dace were captured at 52 of 72 sites (25 of 28 streams) in the upper Cumberland basin using single-pass electrofishing from June to August, 2003. The majority of sites (58%) had catch rates of ten or fewer dace per 200-m site, and 70 or more dace were captured in only 7 of the 72 sites. Single pass catch rates averaged 29 + 37 (mean + SD; n = 52) dace per 200 m in occupied sites, while the median number of captured dace was only 14 per 200 m. Using the Petersen mark-recapture method, population estimates were also conducted on nine sites within five different streams. Population estimates averaged 176 + 133 dace per 200 m (range: 33 - 429), corresponding to density estimates of 27.7 + 19.7 dace per 100 m2 (range: 2.7 - 55.3). Based on these data, a regression model was constructed to obtain population estimates for the other 43 sites in which dace were captured during single-pass electrofishing. Population estimates for these sites averaged 65 + 82 dace per 200 m (range: 4 – 321), corresponding to density estimates of 8.8 + 13.6 dace per 100 m2 (range: 0.3 – 73.9). Overall, population estimates for the 52 sites in which dace were present averaged 84 + 101 dace per 200 m, corresponding to density estimates of 12.1 + 16.3 dace per 100 m2 . Density estimates (56.8 - 73.1 dace per 100m2) reported by Starnes and Starnes (1981) for three sites in Youngs Creek (Whitley County, Kentucky), one of the healthiest known populations at that time, were consistent with the two highest densities identified by Mattingly et al. (2005) and Detar (2004). Population estimates for Big Lick Branch by Leftwich et al. (1997) and Middle Fork Beaver Creek by Leftwich et al. (1995) were 10 - 350 dace per 100m2 and 130 dace per 100m2 (one pool), respectively. These results were considerably higher than those calculated by 36 Mattingly et al. (2005) and Detar (2004), but both studies conducted by Leftwich et al. (1995, 1997) were based on habitat units (pools and riffles), rather than specific stream lengths. Consequently, they may have encountered elevated densities of blackside dace in certain pools. Black and Mattingly (2007) conducted additional presence-absence surveys and performed population estimates on an additional 27 streams (47 200-m reaches) in Kentucky and Tennessee via single-pass backpack electrofishing. Seven sites were double-sampled to allow estimates of population size (Peterson mark-recapture). Blackside dace were found in 18 of 27 streams and 27 of 47 reaches, but most reaches (72%) had catch rates of = 10 dace per 200 m. Occupied reaches had single-pass catch rates of 1 to 96 (21 + 25). Petersen mark-recapture population estimates at seven selected reaches ranged from 54 to 613 dace per 200-m reach and densities averaged 37.5 + 27.2 dace per 100 m2 . These results were used to calibrate single-pass electrofishing results and provide population estimates at the remaining 19 reaches. The mean population estimate was 46 + 84 (range: 2 to 360) dace per 200 m, and associated mean density was 9.3 + 17.6 (range: 0.3 to 73.5) dace per 100 m2 . Population estimates for the 26 reaches harboring dace averaged 92 + 150 dace per 200 m, and associated densities averaged 16.9 + 24.2 dace per 100 m2 . Black et al. (2013) summarized this and some additional information, reporting that dace inhabited 43 of 55 streams and 78 of 119 reaches. The additional data altered density estimates to 14.1 + 19.4 dace per 100 m2. Black et al. (2013)

however, commented that electrofishing sampling efficiency for blackside dace was 0.30. Mattingly et al. (2005) and Black and Mattingly (2007) identified 12 streams as having the most robust populations of the species. Population estimates for these streams exceeded 100 individuals per 200-m reach and ranged from a low of 104 (Fall Branch, TN) to a high of 613 (Breedens Creek, KY) individuals. Strange and Burr (1995) investigated the genetic variation and meta-population structure of the species. Their research revealed the presence of three or four meta-population units: one centered in the upper Poor Fork through Straight Creek stream systems (Group A), another unit comprising the stream systems from Stinking Creek to Youngs Creek (Group B), a third centered around Marsh and Jellico creeks (Group C), and a potential fourth comprised of streams below Cumberland Falls. A cladistic analysis of gene-flow indicated that Group B was the center of dispersal for blackside dace mitochondrial-DNA haplotypes. In spite of several previous surveys (Comiskey and Etnier 1972; Kirsch 1983; Shoup and Peyton 1940; Brazinski 1979; and O'Bara et al. 1982) in the system, the blackside dace was unknown from the BISO NRRA until Scott (2010) reported results of a 2003-2006 fish inventory. Scott reported results of 68 surveys of 41 tributaries (some tributaries were surveyed at more than one site, and some sites were surveyed more than once). These surveys identified blackside dace at two localities in a single headwater stream in the system. The extent of this population's range and size in the BISO NRRA is unknown but Scott (2010) considered the species as rare, comprising only 0.24% of the total individuals he collected at the 82 total sites surveyed in the BISO NRRA. In 2021, the Service (Kentucky Ecological Services Field Office) worked with the Office of Kentucky Nature Preserves, Tennessee Wildlife Resources Agency, and Biological Systems Consultants, LLC, to complete backpack electrofishing surveys across the species' range in Kentucky and Tennessee (Figure 2). Survey locations and sampling methods followed those of Black et al. (2013a), who observed blackside dace at 78 of 119 200-m reaches during field surveys in 2003, 2005, and 2006. We randomly selected and visited a subset (37) of these reaches from June to September 2021. Blackside dace were observed at 27 of 37 reaches, with a total abundance of 655 individuals (range: 1-171 dace per reach) (USFWS, 2022)

Threats and Stressors

Stressor: Barriers
Exposure:
Response:
Consequence:
Narrative: The blackside dace is undoubtedly consumed by natural predators; however, there is no evidence that predation is a significant threat to the species. The species has evolved with various predators over thousands of years and has continued to persist within the watershed. Disease is not known to be a threat to the species. Mattingly and Floyd (2013) summarized the status of blackside dace, and listed a variety of natural (beaver) and anthropogenic impacts affecting 27 blackside dace, including: natural resource extraction; stream channelization; bridge or culvert construction that might prevent barriers to movement; and loss of, and alteration of riparian vegetation. Black et al. (2013) developed a model to predict occurrence of blackside dace. They found that specific conductivity (below 240 microseimens per centimeter (µS/cm) during summer) was a good predictor of blackside dace presence and persistence. However, the mechanism of effect for impacts of elevated conductivity to blackside dace remains unknown. While streams with high levels of conductivity may drain areas affected by various land uses (natural gas extraction, silviculture, and urbanization), coal mining has been implicated as a contributor to the species' decline, and surface coal mining can also increase the conductivity of

receiving streams (McAbee et al. 2013).

Stressor: Water quality degradation
Exposure:
Response:
Consequence:
Narrative: A significant threat to the blackside dace is water quality degradation of streams caused by a variety of non-point source pollutants. Surface coal mining represents a major source of these pollutants because it has the potential to contribute high concentrations of dissolved metals and other solids that may elevate stream conductivity, increase sulfate levels, and can cause wide fluctuations in stream pH (Curtis 1973; Pond 2004; Hartman et al. 2005; Mattingly et al. 2005; Pond et al. 2008; Palmer et al. 2010; USEPA 2011a; Black et al. 2013a, b). The upper Cumberland River system of Kentucky and Tennessee has been mined extensively, and these activities continue to occur throughout the system.

Stressor: Sedimentation/siltation
Exposure:
Response:
Consequence:
Narrative: Sediment (siltation) has been listed repeatedly by the KDOW as the most common stressor of aquatic communities in the upper Cumberland River system (KDOW 2006, 2011, 2013). Sedimentation comes from a variety of sources, but KDOW identified the primary sources of sediment as loss of riparian habitat, surface coal mining, legacy coal extraction, logging, and land development (KDOW 2008, 2011, 2013). All of these activities can result in canopy removal, channel disturbance, and increased siltation, thereby degrading habitats used by fishes for both feeding and reproduction.

Stressor: Reduced genetic exchange
Exposure:
Response:
Consequence:
Narrative: The disjunct nature of some blackside dace populations restricts the natural exchange of genetic material between populations. The localized nature and small size of many populations also makes them vulnerable to extirpation from intentional or accidental toxic chemical spills, habitat modification, progressive degradation from runoff (non-point source pollutants), natural catastrophic changes to their habitat (e.g., flood scour, drought), and other stochastic disturbances, such as loss of genetic variation and inbreeding. For example, inbreeding and loss of neutral genetic variation associated with small population size can further reduce the fitness of the population (Reed and Frankham 2003), subsequently accelerating population decline (Fagan and Holmes 2006).

Recovery

Recovery Actions:

- Preserve genetic diversity – Strange and Burr (1995) recommended that recovery plans treat the meta-populations as management units, employing carefully planned reintroductions 37 and habitat protection. Translocation of the species between meta-populations was discouraged; rather, they recommended that translocations be made from sites geographically proximate to the site of the reintroduction and preferably within the same stream system. Their data further indicated considerable gene-flow within meta-populations, suggesting that protection of dispersal corridors may be as important as protecting actual habitats.

- Corridor protection – Priority should be given to corridor protection, allowing the species to reinvade formerly occupied habitats on its own.
- RECOMMENDATIONS FOR FUTURE ACTIONS The following recovery and conservation recommendations are based on actions identified in the species' recovery plan (USFWS 1988), other activities summarized by Mattingly and Floyd (2013), and new ideas generated during the preparation of this five-year review. The recommended actions are listed in no particular order of priority. ⍰ Continue to utilize existing legislation and regulations to protect the species and its habitats (e.g., ESA, federal and state surface mining laws, US Clean Water Act and other state water quality regulations, Federal Energy Regulatory Commission licensing). ⍰ Continue cooperative efforts such as habitat conservation plans, Farm Bill programs, Partners for Fish and Wildlife program projects, state stream mitigation programs, and other resources to address threats and to protect, enhance, and restore dace populations and habitats. ⍰ Conduct research to address information needs with regard to the species' biology, ecology, behavioral patterns, and early life history: o The species' genetic diversity, level of genetic exchange, and viability of populations o The species' response and vulnerability to elevated conductivity o The species' swimming performance as it relates to culvert/bridge design o Development of a sound, cost-effective, range-wide monitoring strategy o The species' response to the potential loss of eastern hemlocks o The species' response to climate change o Interactions with other species (e.g., redbreast sunfish) o Impacts of beaver colonization across the range o The species' habitat characteristics as it relates to stream restoration efforts o The species' early life history stages – biological and habitat needs ⍰ Work cooperatively with federal, state, and private partners to develop a range-wide conservation strategy for blackside dace that (1) builds on recovery actions identified in the species' recovery plan and (2) incorporates the best available scientific information on the species' biology, status, and threats as outlined in this five-year review; ⍰ Continue to monitor extant populations and search for new populations using a standardized monitoring protocol to help us determine and evaluate viability across its range. Survey activities should be prioritized to include those streams for which recent survey data is lacking or streams in which the species appears to be vulnerable. A preliminary list of these streams is provided below: o Acorn Fork, Knox County, KY o Bailey Branch, Whitley County, KY o Bain Branch (Hubbs Creek), Knox County, KY o Bennetts Fork, Claiborne County, TN o Bucks Branch, Whitley County, KY o Capuchin Creek headwaters, Campbell/Scott Counties, TN o Cannon Creek, Bell County, KY o Colliers Creek, Letcher County, KY o Drury Branch, McCreary County, KY o Fall Branch, Campbell County, TN o Fourmile Run, Bell County, KY o Hatfield Creek system, Campbell County, TN o Hinkle Branch, Knox County, KY o Hunting Shirt Branch, Knox County, KY o Jellico Creek headwaters, Scott County, TN o Lick Fork, Campbell County, TN o Louse Creek and Jim Branch, Campbell County, TN o Meadow Branch, Letcher County, KY o Meadow Fork, Letcher County, KY o Ned Branch, Laurel County, KY o Rock Creek system, McCreary County, KY & Scott County, TN o Seng Branch, Whitley County, KY o Slick Shoals Branch, Whitley County, KY o Sugar Run, Bell County, KY o Tackett Creek (headwaters), Claiborne County, TN o Turkey Creek, Knox County, KY o Tyes Fork, Whitley County, KY o Youngs Creek, Whitley County, KY ⍰ Initiate other recovery actions as specified in the range-wide conservation strategy and revised recovery plan. ⍰ Revise the current listing to reflect the taxonomic

change and the species' extended range into Virginia (USFWS, 2015).

- Recovery Priority Number: 11

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS ● Continue to utilize existing legislation and regulations to protect the species and its habitats (e.g., ESA, federal and state surface mining laws, Clean Water Act, state water quality regulations). ● Continue to protect, restore, and enhance habitat quality across the species' range. Federal, state, and private parties should continue to work cooperatively (through Farm Bill programs, Partners for Fish and Wildlife projects, Kentucky Wild Rivers Program, etc.) to restore and protect habitats for the species. ● Conduct periodic monitoring (five-year intervals) of extant populations and search for new populations following methods used by Black et al. (2013). ● Consult with agency partners and species experts to determine what biological or ecological studies are needed to better understand the species' life history and sensitivity to threats (e.g., elevated conductivity). Using this information, determine what management strategies are needed to improve the species' status across its range. ● Continue research on population genetics; evaluate gene flow and genetic diversity across the species' range (USFWS, 2022).

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SPECIES ACCOUNT: *Chrosomus saylori* (Laurel dace)

Species Taxonomic and Listing Information

Listing Status: Endangered; August 9, 2011 [USFWS 2014], Region 4 - Tennessee

Physical Description

Laurel dace have two continuous black lateral stripes and black pigment covering the breast and underside of the head of nuptial (breeding) males (Skelton 2001). The maximum standard length (SL) observed is 6.2 centimeters (cm) (2.4 inches (in)) (Skelton 2001). While the belly, breast, and lower half of the head are typically a whitish-silvery color, at any time of the year laurel dace may develop red coloration below the lateral stripe that extends from the base of the pectoral fins to the base of the caudal fin (Skelton 2001) [USFWS 2014].

Taxonomy

The Laurel dace is a member of the redbelly dace group (genus Chrosomus), comprising seven recognized and one undescribed species in North America. Originally described in the genus Phoxinus, a revision by Strange and Mayden (2009) elevated the subgenus Chrosomus and reassigned all seven North American Phoxinus species to this genus [USFWS 2014].

Historical Range

Historically, this species is known from seven streams, and currently it occupies six of those. The fish is believed extirpated from Laurel Branch [USFWS 2014].

Current Range

Laurel dace persist in three creek systems on the Walden Ridge of the Cumberland Plateau in Tennessee. Only a few individuals have been collected from the two creek systems in the southern part of their range, Soddy and Sale creeks, while laurel dace are more abundant in headwater streams of the Piney River system to the north [USFWS 2014].

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 10/16/2012.

Legal Description

On October 16, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Chrosomus saylori (Laurel dace) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes six critical habitat units (CHUs) in Tennessee (77 FR 63604-63668).

Critical Habitat Designation

The critical habitat designation for Chrosomus saylori includes six CHUs in Bledsoe, Rhea, and Sequatchie Counties, Tennessee (77 FR 63604-63668).

Units 1, 2, and 3: Bumbee Creek and Youngs Creek, Bledsoe and Rhea Counties, Tennessee; and Moccasin Creek, Bledsoe County, Tennessee. (i) Unit 1 includes 7.8 river kilometers (rkm) (4.8

river miles (rmi)) of Bumbee Creek from its headwaters in Bledsoe County, downstream to its confluence with Mapleslush Branch in Rhea County, Tennessee.

(ii) Unit 2 includes 7.9 rkm (4.9 rmi) of Youngs Creek from its headwaters in Bledsoe County, downstream to its confluence with Moccasin Creek in Rhea County, Tennessee.

(iii) Unit 3 includes 9.0 rkm (5.6 rmi) of Moccasin Creek from its headwaters downstream to 0.1 rkm (0.6 rmi) below its confluence with Lick Creek in Bledsoe County, Tennessee.

Unit 4: Cupp Creek, Bledsoe County, Tennessee. (i) Unit 4 includes 5.0 rkm (3.1 rmi) of Cupp Creek from its headwaters downstream to its confluence with an unnamed tributary in Bledsoe County, Tennessee.

Unit 5: Horn Branch, Bledsoe County, Tennessee. (i) Unit 5 includes 4.0 rkm (2.5 rmi) of Horn Branch from its headwaters downstream to its confluence with Rock Creek, Bledsoe County, Tennessee.

Unit 6: Soddy Creek, Sequatchie and Bledsoe Counties, Tennessee. (i) Unit 6 includes 8.4 rkm (5.2 rmi) of Soddy Creek from its headwaters in Sequatchie County, downstream to its confluence with Harvey Creek in Sequatchie County, Tennessee.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Chrosomus saylori critical habitat consists of five components in Tennessee (77 FR 63604-63668):

(i) Pool and run habitats of geomorphically stable, first- to secondorder streams with riparian vegetation; cool, clean, flowing water; shallow depths; and connectivity between spawning, foraging, and resting sites to promote gene flow throughout the species’ range.

(ii) Stable bottom substrates composed of relatively silt-free gravel, cobble, and slab-rock boulder substrates with undercut banks and canopy cover. Relatively silt-free is defined for the purpose of this rule as silt or fine sand within interstitial spaces of substrates in amounts low enough to have minimal impact to the species.

(iii) An instream flow regime (magnitude, frequency, duration, and seasonality of discharge over time) sufficient to provide permanent surface flows, as measured during years with average rainfall, and to maintain benthic habitats utilized by the species.

(iv) Adequate water quality characterized by moderate stream temperatures, acceptable dissolved oxygen concentrations, moderate pH, and low levels of pollutants. Adequate water quality is defined for the purpose of this rule as the quality necessary for normal behavior, growth, and viability of all life stages of the laurel dace.

(v) Prey base of aquatic macroinvertebrates, including midge larvae, caddisfly larvae, and stonefly larvae.

Special Management Considerations or Protections

The six units we are designating as critical habitat will require some level of management to address the current and future threats to the physical and biological features of the laurel dace. These units are located on private property and are not presently under the special management or protection provided by a legally operative plan or agreement for the conservation of the species. Various activities in or adjacent to these areas of critical habitat may affect one or more of the physical and biological features. For example, features in this critical habitat designation may require special management due to threats posed by resource extraction (coal and gravel mining, silviculture, natural gas and oil exploration activities), agricultural activities (row crops and livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, nonpoint source pollution arising from a wide variety of human activities, and canopy loss caused by infestations of the hemlock woolly adelgid. These threats are in addition to random effects of drought, floods, or other natural phenomena. Other activities that may affect physical and biological features in the critical habitat units include those listed in the Effects of Critical Habitat Designation section below. Management activities that could ameliorate these threats include, but are not limited to: Use of BMPs designed to reduce sedimentation, erosion, and bank side destruction; moderation of surface and ground water withdrawals to maintain natural flow regimes; increase of stormwater management and reduction of stormwater flows into the systems; preservation of headwater streams; regulation of off-road vehicle use; and reduction of other watershed and floodplain disturbances that release sediments, acid mine drainage, pollutants, or nutrients into the water. In summary, we find that the areas we are designating as critical habitat for the laurel dace contain the physical or biological features for the species, and that these features may require special management considerations or protection. Special management consideration or protection may be required to eliminate, or to reduce to negligible levels, the threats affecting the physical or biological features of each unit.

Life History

Feeding Narrative

Adult: The laurel dace is an invertivore that feeds on larval aquatic insects (Tricoptera, Plecoptera, and Diptera) and some plant material. The feeding strategy is inferred to be generalist [NatureServe 2015]. It competes with sunfishes and bass for food resources, and is presumed to require adjacent riparian vegetation, based on the fact that it is mainly found in these areas. Sedimentation can adversely affect feeding by altering the prey base and visibility of prey [inferred from USFWS 2014].

Reproduction Narrative

Adult: The laurel dace is oviparous [NatureServe 2015]. Parental care is assumed low based on known behavior of similar species. The species typically lives up to 3 years. It exhibits nuptial behavior. Sedimentation can adversely affect reproduction by reducing visual cues and interstitial spaces for benthic egg deposition [USFWS 2014].

Tolerance Ranges/Thresholds

Adult: Low [inferred from USFWS 2014]

Habitat Narrative

Adult: The laurel dace lives in freshwater riverine environments. It has been observed in creeks and pools of moderate-high gradient. The species requires reasonable water quality, which has been identified as a possible limiting factor for success. [NatureServe 2015]. The laurel dace relies on substrates comprising a mix of cobble, rubble, and boulder and has mainly been observed in areas adjacent to dense riparian vegetation. The ecological integrity of the community is presumed to be moderate, while tolerance ranges/thresholds are relatively low [inferred from USFWS 2014]. Laurel Dace are known from headwater tributaries on Walden Ridge. This is a small fish from the family Cyprinidae that is normally found or collected from pools or slow runs from undercut banks or under slab boulders. The riparian vegetation surrounding the first or second order streams where Laurel Dace occur includes mountain laurel (Kalmia latifolia), rhododendron (Rhododendron sp.), and eastern hemlock (Tsuga canadensis) (USFWS, 2016).

Dispersal/Migration

Motility/Mobility

Adult: Moderate [inferred from USFWS 2014]

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory [inferred from NatureServe 2015]

Dispersal

Adult: Low [inferred from USFWS 2014]

Dispersal/Migration Narrative

Adult: The laurel dace exhibits moderate mobility and low dispersal. Dispersal of the laurel dace presumably would increase with increasing access to cold water and stronger in-stream flow. Resultantly, climate change and human response to it have been identified as threats to extirpation due to their effect on species dispersal [USFWS 2014]. The species is non-migrant [inferred from NatureServe 2015].

Additional Life History Information

Adult: Climate change and human response to it have been identified as threats to extirpation due to their effect on species dispersal [USFWS 2014].

Population Information and Trends

Population Trends:

Declining (USFWS, 2021)

Adaptability:

Moderate [inferred from USFWS 2014]

Additional Population-level Information:

This fish is fairly common to abundant where it occurs (Skelton 2001) [NatureServe 2015]

Population Narrative:

When listed in 2011, and at the time of the Service’s recovery plan for the species in 2016, extant populations of the Laurel Dace were known from six streams in Bledsoe and Rhea counties, Tennessee. Since that time, the species has declined and now occupies only portions of three headwater streams - Bumbee Creek and Youngs Creek in the northern metapopulation and Horn Branch in the southern metapopulation. Additionally, the population in Horn Branch, compared to capture records before 2014, is almost undetectable by current survey methods. Increased sedimentation associated with vegetable production (row-crop agriculture) and potential predation by sunfishes continue to threaten the species. Successful captive propagation and establishment of an ark population would reduce the species' risk of extinction, but success of these efforts is far from certain. Without suitable habitat free from continued threats, the potential for successful reintroductions of lost populations is limited. The species remains highly vulnerable to stochastic events such as droughts or toxic chemical spills. (USFWS, 2021)

Threats and Stressors

Stressor: Siltation
Exposure:
Response:
Consequence:
Narrative: Siltation is the most significant stressor. It is caused by excessive releases of sediment from activities such as resource extraction (e.g., coal mining, silviculture, natural gas development), agriculture, road construction, and urban development [USFWS 2011].

Stressor: Siltation
Exposure:
Response:
Consequence:
Narrative: Siltation is the most significant stressor. It is caused by excessive releases of sediment from activities such as resource extraction (e.g., coal mining, silviculture, natural gas development), agriculture, road construction, and urban development [USFWS 2011].

Stressor: Disturbance of riparian corridors
Exposure:
Response:
Consequence:
Narrative: Disturbance of riparian corridors represent a potential stressor to this species [USFWS 2011].

Stressor: Changes in channel morphology
Exposure:
Response:
Consequence:
Narrative: Changes in channel morphology represent a potential stressor to this species [USFWS 2011].

Stressor: Nonpoint source pollution from land surface runoff
Exposure:
Response:
Consequence:
Narrative: Non-point source pollution from land surface runoff can originate from virtually any land use activity and may be correlated with impervious surfaces and storm water runoff.

Pollutants may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, pharmaceuticals, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streams such that the habitat and food sources for species like the laurel dace are negatively impacted [USFWS 2011].

Stressor: Conversion of forest to residential uses
Exposure:
Response:
Consequence:
Narrative: Conversion of native hardwood forests to residential uses, pasture, crop, and pine monocultures has likely altered hydrology in the catchments of streams where laurel dace occur [USFWS 2011].

Recovery

Reclassification Criteria:
Suitable instream habitat, flows, and water quality for laurel dace, as defined by recovery tasks 5.1 and 5.2, exist in occupied streams [USFWS 2014].

Viable populations are present throughout suitable habitat in Bumbee, Moccasin, and Youngs creeks, and at least two of the following streams: Soddy or Cupp creek or Horn Branch [USFWS 2014].

Delisting Criteria:
Suitable instream habitat, flows, and water quality for laurel dace exist in all occupied streams, and mechanisms exist to ensure that land use activities (including road maintenance) in catchments of streams inhabited by laurel dace will be compatible with the species' conservation for the foreseeable future [USFWS 2014].

Viable populations are present throughout suitable habitat in Bumbee, Moccasin, Youngs, Soddy, and Cupp creeks and Horn Branch, and one additional viable population exists, either through reintroduction into Laurel Branch or discovery of an additional wild population [USFWS 2014].

Recovery Actions:
- Protect laurel dace habitat via land acquisition, conservation easements, or other mechanisms to reduce threats to instream and riparian habitat [USFWS 2014].
- Map suitable habitat in streams where laurel dace are extant or occurred historically, identify streams on Walden Ridge with suitable habitat but no known records of occurrence, and periodically conduct surveys for previously undetected populations and to determine whether populations are still extant in occupied streams [USFWS 2014].
- Develop a program to monitor trends in distribution and demographic structure of laurel dace populations, habitat conditions, and land use in catchments of laurel dace streams [USFWS 2014].
- Conduct baseline genetic analysis and establish protocol for periodic monitoring to detect trends in genetic variation and structure among populations [USFWS 2014].

- Determine life history, interspecies interactions, and tolerance to environmental stressors of the laurel dace, and conduct population viability analysis [USFWS 2014].
- Evaluate stream crossings as fish passage barriers or nonpoint pollutant sources and reduce impact if necessary [USFWS 2014].
- Establish protocols and plan for captive propagation to support research and reintroduction or augmentation [USFWS 2014].
- Develop informational materials and conduct outreach to encourage public participation in laurel dace recovery effort [USFWS 2014].
- The Tennessee Wildlife Resources Agency (TWRA) and Tennessee Tech University (TTU) initiated contact with Timberland Investment Resources (TIR), a company with extensive land holdings in the catchments of Bumbee and Youngs creeks. Through this contact, the TWRA, TTU, and the Service have explored opportunities for conservation agreements and improvements to stream crossings, and attempted to negotiate access to waters passing through TIR lands in order to conduct surveys for laurel dace [USFWS 2014].
- During the summer of 2007, TWRA conducted surveys in laurel dace streams using minnow traps. This effort primarily focused on the streams inhabited by the southern populations (the populations in the Sale and Soddy Creek systems), while including some sampling in streams 22 inhabited by the northern population (in the Piney River system). While conducting these surveys, TWRA biologists reconnoitered land use in the watersheds containing laurel dace to identify private lands towards which future cooperative efforts should be directed [USFWS 2014].

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FURTHER ACTIONS The following actions should be undertaken for the Laurel Dace: • Reduce sediment inputs in Youngs Creek. • Establish ark populations for both the northern and southern metapopulations. • Conduct fine-scale genetic analysis to determine suitable reintroduction possibilities. • Complete a captive propagation plan for the species. • Refine captive propagation techniques, including ways to prevent or account for mycobacterium. • Conduct research into the causes and impacts of Youngs Creek trematode infections. • Complete annual monitoring for populations in Bumbee Creek, Youngs Creek and Horn Branch, and complete population estimates for all three streams. • Search for previously unknown populations. • Determine stressor tolerance of a surrogate species, Tennessee Dace (Chrosomus tennesseensis), in laboratory studies and look for other factors limiting the species • Protect existing Laurel Dace watersheds through acquisition, easement, technical assistance, or other conservation measures. Pursuing landowner agreements through the Partners for Fish and Wildlife Program may be particularly attractive. • Reduce sedimentation across the species' historical range by working with agricultural landowners and developers. • Restore habitat in occupied and unoccupied streams. • Monitor water quality in occupied and unoccupied streams. • Reintroduce Laurel Dace into currently unoccupied streams. • Investigate mycobacterium levels in wild populations of Laurel Dace. (USFWS, 2021)

References

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U.S. Fish and Wildlife Service. 2012. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for the Cumberland Darter, Rush Darter, Yellowcheek Darter, Chucky Madtom, and Laurel Dace. Final rule. 77 FR 63604-63668 (October 16, 2012).

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USFWS. 2011. Endangered and Threatened Wildlife and Plants

Endangered Status for the Cumberland Darter, Rush Darter, Yellowcheek Darter, Chucky Madtom, and Laurel Dace

Final Rule. 76 Federal Register 153. August 11, 2011. Pages 48722-48741.

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SPECIES ACCOUNT: *Cottus paulus (=pygmaeus)* (Pygmy Sculpin)

Species Taxonomic and Listing Information

Listing Status: Threatened; September 28, 1989 [USFWS 1991] Region 4 - Alabama (NatureServe 2015)

Physical Description

This species rarely exceeds 45 millimeters (mm) or 1.8 inches (in) in total length. The head is large, body moderately robust, and the lateral line is incomplete. Coloration varies by sex, maturity, and breeding condition, while pigmentation is generally consistent (Williams 1968). Pigmentation generally consists of up to three dorsal saddles and mottled or spotted fins. Juveniles have a grayish black body with three light colored saddles. Upon maturity, the body color becomes lighter, and the grayish black color that remains forms two dark saddles. In juveniles, the head is black, changing to white with small scattered melanophores in adults. In breeding males, the dark spots in the spinous dorsal fin enlarge and become more intense and the fin margin becomes reddish orange. The entire body becomes suffused with black pigment which almost completely conceals the underlying pattern. The breeding color of females tends to be slightly darker than in non-breeding females [USFWS 1991].

Taxonomy

This species formerly was known as Cottus pygmaeus, but that specific name is preoccupied in the genus Cottus, so Williams (2000) proposed the substitute name C. paulus. (NatureServe, 2015)

Historical Range

See current range/distribution. Historic records are not available to document if the pygmy sculpin occurred below the confluence of dry Creek prior to the water quality degradation. The historic range may have extended downstream of the Dry Creek confluence prior to the occurrence of environmental pollution [USFWS 1989].

Current Range

The only known population of pygmy sculpins is in Coldwater Spring and the spring run [USFWS 1989].

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

<u>Adult:</u> The pygmy sculpin is an inverti vore generalist that feeds primarily on isopods, amphipods, gastropods, andtrichopterans. Juveniles eat chironomid larvae, copepods, and ostracods [NatureServe 2015]. Adults occasionally feed upon C. pymaeus eggs. Food is distributed within the Coldwater Spring Creek. It is presumed that suitable water quality is needed to support the prey base for this species [inferred from USFWS 1991].

Reproduction Narrative

Adult: The pygmy sculpin is oviparous and is presumed to provide low parental care/investment. Clutch size ranges from 18-59 eggs and is related to individual size, which are deposited in clumps underneath rocks and bricks. More than one female may deposit eggs in a nest. Sexual maturity is reached when the female is 25-29 cm in length (USFWS, 1991). The species probably spawns throughout the year, peaking in April-August (NatureServe, 2015).

Site Fidelity

Adult: High (inferred from USFWS, 1991)

Habitat Narrative

Adult: The species inhabits the Coldwater Spring, a freshwater impounded spring (USFWS, 2008). The spring experiences low flow rates relative to comparable springs in the region. Abiotic habitat resources needed include rock and gravel substrate for runs, and flat rocks to facilitate reproduction through egg deposit (NatureServe, 2015). Site fidelity is inferred to be high based on its very limited range (USFWS, 1991).

Dispersal/Migration

Motility/Mobility

Adult: Moderate (inferred from USFWS, 1991)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (inferred from USFWS, 1991)

Dispersal

Adult: Low (inferred from USFWS, 1991)

Dispersal/Migration Narrative

Adult: The species is non-migratory. Its mobility and dispersal are inferred to be moderate and low, respectively, based on its free-ranging movements but very limited range (USFWS, 1991).

Population Information and Trends

Population Trends:

Stable (USFWS, 2008)

Population Size:

12,361-22,662 (USFWS, 2024)

Resistance to Disease:

Disease is not known to be a problem for this species (USFWS, 2008)

Additional Population-level Information:

Species has not been surveyed since 1999 (USFWS, 2008)

Population Narrative:

The species has not been surveyed since 1999, but appears to have a stable population in Coldwater Spring. Past surveys indicate population can range from 1,710-25,000 individuals in the spring pool, and 2,500-5,392 in the spring run. Disease is not known to be a problem for this species (UFSWS, 2008). Its resiliency, representation, and redundancy are inferred to be low based on the pygmy sculpin's very limited range and presumed vulnerability to stochastic events (USFWS, 1991). In 1973 the population of pygmy sculpins in the Coldwater Spring run was estimated at 2,250 to 2,700 individuals (Service 1991). However, the abundance of the pygmy sculpin in Coldwater Spring pool was not estimated. Estimates by Catchings (1992) ranged from 1,710 to 2,722 in the spring pool and as many as 5,392 in the spring run. Stiles (1999) estimated the population numbers of pygmy sculpins within the spring pool from 1997 to 1998 to be as high as 25,000 individuals, and within the spring run, during the same time, as high as 2,500. In 2014, a longterm sampling protocol was developed (Matechik 2014). Subsequently, the Alabama Department of Conservation and Natural Resources (ADCNR), Division of Wildlife and Freshwater Fisheries implemented methods from the sampling protocol and provide estimates of density as individuals per square meter (Figure 2) from 2015-2018 (Rider et al. 2016; Rider and Miles 2017; Rider and Miles 2018). Additional densities of pygmy sculpin were provided by Tetra Tech (2023) which implemented a sampling methodology that was modified from Matechik 2014 (Figure 2). Generally, methods recommended by Matechik (2014) and implemented by ADCNR estimate a mean number of the pygmy sculpin calculated per square meter at 50 randomly selected quadrates in Coldwater Spring run and in the spring pool. In the spring pool, densities were estimated by cobble and nostoc (defined as a mixture of sand, algae, and cyanobacteria) habitat types and excluded vegetated habitats from analysis. TetraTech modified these methods by utilizing an underwater drone that selected 50 unique quadrates that were 0.5 meter2 and included vegetated habitats in the survey. Using these modified methods, TetraTech estimated a population size that ranged from 12,361 in December 2020 to 22,662 in December 2021. Based on approximately seven years of data, mean densities appear consistent. However, statistical significance testing has not been conducted and the modified methods implemented after 2020 cannot be compared to data collected between 2015 and 2018 (USFWS, 2024).

Threats and Stressors

Stressor: Groundwater degradation (USFWS, 1991)
Exposure:
Response:
Consequence:
Narrative: The threat from ground water degradation is potentially the most serious. Trichloroethylene is present in Coldwater Spring at low concentrations (Environmental Science and Engineering, Inc., 1986). This chemical is present in the subsurface water on the Depot in strong concentrations and may be moving through the aquifer to Coldwater Spring (Kangas 1987). However, the basis for attributing the entire pollution of Coldwater Spring to the Depot is not conclusive. There are low concentrations of other contaminants in the aquifer at the Depot which have not been reported from Coldwater Spring (Kangas 1987). Other sources within the 233 square kilometer (90 square mile) recharge area may be contributing to pesticide levels in the Spring. Surface water contamination may be preventing the sculpin from occupying potential habitat in Dry Creek (USFWS, 1991).

Stressor: Collecting of species [USFWS 1991].

Exposure:
Response:
Consequence:
Narrative: Collection of this species could be a limiting factor due to its very restricted habitat. As long as the Anniston Water and Sewer Department manages Coldwater Spring, it is unlikely that collecting will pose a serious threat because access is controlled [USFWS 1991].

Stressor: Predation (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: A number of species that are potential predators of the pygmy sculpin occur within Coldwater Spring such as water snakes (Nerodia spp.), chain pickerel (Esox niger), and banded sculpin (Cottus carolinae), though, direct evidence of such interactions is scant. Further, Williams (1968) noted that the banded sculpin was restricted to the “edge of the spring” and found this to be “significant”. In contrast, the pygmy sculpin was found to be the most abundant species of fish throughout Coldwater Spring (Williams 1968). Adult pygmy sculpins are known to occasionally feed upon conspecific sculpin eggs. Males have been observed to consume entire clutches of eggs when taking over existing nests during brooding (Johnston 2000). Crayfish (such as Cambarus latimanus) also eat pygmy sculpin eggs (Johnston and Knight 2004). Crayfish are observed frequently and appear to occur at high densities in Coldwater Spring. While predation likely occurs, we currently do not have any information to indicate that mortality due to predation is excessive and resulting in negative population growth rates. Similarly, there is no evidence to suggest that disease poses a threat to the species at-this-time (USFWS, 2024).

Stressor: Climate change (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: Climate changes that are and will be impacting Alabama also have the potential to impact pygmy sculpin. In the future temperatures are expected to increase and annual precipitation is highly variable (Runkle et al. 2022). These two variables taken individually or together could result in negative impacts on the species, with increases in temperature resulting in changes outside of the biological thresholds for the species discussed above and with periodic drought potentially impacting habitat availability and resulting in reduced survival of individuals or reduced reproductive success. Loss of habitat availability for nests may result in increased intraspecific nest predation as individuals take over nesting spaces. Alternatively extreme precipitation events could wash pollutants from headwaters and other areas within the watershed down into habitats the species is using and decrease survival and reproductive success. In the near future additional information will help the Service determine if these impacts will negatively impact the species viability (USFWS, 2024),

Recovery

Reclassification Criteria:
None. See delisting criteria.

Delisting Criteria:

The first recovery objective will be satisfied when all recovery tasks have been fully implemented. The pygmy sculpin will be considered for delisting when all recovery tasks have been fully implemented and 5 years of consecutive data indicate the existence of five or more protected, viable populations in separate drainages fed by three or more separate aquifers (USFWS 1991).

Recovery Actions:

- Monitor population and survey potential habitat for additional populations and potential transplant sites (USFWS, 1991).
- Protect and secure the pygmy sculpin; its habitat; and the surface and subsurface drainage systems that support them [USFWS 1991].
- Investigate and implement feasible methods of increasing the quantity and quality of pygmy sculpin habitat [USFWS 1991].
- Develop and implement a strategy to rescue the species in the event Coldwater Spring becomes unsuitable habitat [USFWS 1991].
- The Anniston Army Depot is working on methods to remove trichloroethylene and other contaminants from the aquifer under the Depot. Unless this adversely impacts the Spring flow, it is expected the cleanup actions will benefit the sculpin. As a component of their aquifer cleanup activity, the Depot is monitoring the quality of water in the aquifer from both on-depot and off-depot wells (USFWS, 1991).
- The U.S. Geological Survey has delineated the area that is believed to be the recharge area for Coldwater Spring (Scott et ii.. 1987). This area is some 233 square kilometers (90 square miles) and includes a portion of the Depot, the City of Anniston, Fort McClellan, the City of Jacksonville, and other suburban areas.
- Prior to listing the pygmy sculpin, the Fish and Wildlife Service alerted the Federal Highway Administration and the Alabama Highway and Transportation Department to the potential impacts of a roadway being considered proximate to Coldwater Spring. This conference resulted in consideration of other routing alternatives. If an alternative is selected that may affect the pygmy sculpin, it will be subject to Section 7 consultation.

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES A detailed discussion of recovery actions and criteria are presented in the Recovery Plan (Service 1991). In the course of this status review new and/or targeted potential recovery activities were identified and are included below. Recovery Activities • Continue working closely with the Anniston Water Works and Sewer Board regarding: o Water extraction, quality and quantity. o Watershed management practices for the pygmy sculpin. • Existing regulations and land management laws within the recharge area should be enforced. • Develop a comprehensive land use and impact database and conservation strategy on the 90 square mile recharge are of Coldwater Spring. Work through various agreements, memorandums of understanding, partnerships and funding mechanisms, with private landowners, municipalities, Calhoun County, State of Alabama and Federal Agencies such as the Natural Resources Conservation Service, Environmental Protection Agency, and Department of the Army, to protect the recharge area. • Captive propagation work o Plan should be developed. o Propagation studies and efforts should be undertaken to bolster redundancy. • A disaster recovery program for the species should be developed and implemented; such a plan should include incorporation of an ark population in aquaria or the development of a surrogate spring refugia. Monitoring and Research Activities • A consistent monitoring plan should be continued for the pygmy sculpin and Coldwater Spring recharge area. • Research to understand the effects of contaminants present or likely to become present in Coldwater Spring on the pygmy sculpin or other species of the genus Cottus as a surrogate should be conducted (USFWS, 2024).

Additional Threshold Information:

- a
- a

References

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NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

USFWS 2008. Pygmy Sculpin (Cottus paulus): 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Southeast Region (R4), Jackson, Mississippi. July 28, 2008. 13 p. USFWS. 2024. Pygmy Sculpin (Cottus paulus [=pygmaeus]) 5-Year Status Review: Summary and Evaluation. Atlanta Regional Office. Alabama Ecological Services Field Office. Daphne, AL. 10 pp.

USFWS. 1991. Pygmy Sculpin (Cottus pygmaeus) Recovery Plan. Jackson, Mississippi pp. 13.

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b

SPECIES ACCOUNT: *Cottus specus* (Grotto Sculpin)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/25/2013; Great Lakes-Big Rivers Region (Region 3) (USFWS, 2013)

Physical Description

This sculpin has a suite of cave-adapted features, such as small, nearly non-functional eyes; reduced skin pigmentation; low metabolic rate, among other features (Burr et al. 2001, USFWS 2002). (NatureServe, 2015)

Taxonomy

Cottus specus represents the first description of a cave species within Cottus (Adams et al. 2013)(NatureServe, 2015)

Historical Range

Historical range is not known to be different from current distribution. (USFWS, 2012)

Current Range

This species is restricted to five cave systems in two karst (limestone regions characterized by sink holes, abrupt ridges, caves, and underground streams) areas, the Central Perryville Karst and Mystery-Rimstone Karst in Perry County, southeastern Missouri (USFWS 2009). The current overall range is estimated to encompass approximately 260 square kilometers. (USFWS, 2012)

Critical Habitat Designated

Yes; 9/25/2013.

Legal Description

On September 25, 2013, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Cottus specus (Grotto Sculpin) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes four critical habitat units (CHUs) in Missouri (78 FR 58923-58938).

The critical habitat designation for Cottus specus includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Cottus specus.

Critical Habitat Designation

The critical habitat designation for Cottus specus includes four CHUs in Perry County, Missouri (78 FR 58923-58938; 77 FR59488-59515).

Unit 1: Central Perryville Karst Area, Perry County, Missouri: Unit 1 includes all aquatic habitats within the recharge area of the Moore Cave System, the Crevice Cave System, Ball Mill Spring, and Keyhole Spring. The entire area covers approximately 45.61 km\2\ (17.61 mi\2\). The Moore Cave System Recharge Area encompasses approximately 10.23 km\2\ (3.95 mi\2\) and drains north from the edge of Perryville and discharges at Blue Spring on Blue Spring Branch; it can overflow from an adjacent spring called Blue Spring Overflow or Blue Spring Resurgence

(Moss and Pobst 2010, pp. 147, 183). The recharge area of Crevice Cave includes Mertz Cave and Resurgence, Zahner Cave, Doc White Spring, Hogpen Spring, Herberlie Resurgence, Circle Drive Resurgence, Rob Roy Sink, Rozier Sink, Edgemont Sink, Shoe Factory Sink, and Lurk Sink, and has been estimated to be approximately 30.33 km\2\ (11.71 mi\2\) (Moss and Pobst 2010, pp. 151-152). Ball Mill Spring feeds portions of the Blue Spring Branch (a separate proposed critical habitat unit (Unit 3) outlined below) and the recharge area for this water source is approximately 1.71 km\2\ (0.66 mi\2\) (Moss and Pobst 2010, p. 153). Keyhole Spring includes Keyhole Resurgence, and the total recharge area has been estimated to be 3.34 km\2\ (1.29 mi\2\) (Moss and Pobst 2010, p. 152). The recharge area for Crevice Cave contains the city of Perryville. In addition to the threats that may require special management considerations or protections outlined above for all units, this unit is negatively affected by urban growth and development that might impact water quality, such as hazardous waste facilities, underground storage tanks, wastewater discharges, and poorly maintained septic systems in and around the city (Pobst and Taylor 2008, p. 69; Moss and Pobst 2010, p. 164).

Unit 2: Mystery-Rimstone Karst Area, Perry County, Missouri: Unit 2 includes all aquatic habitats within the recharge zone of Mystery Cave, Rimstone River Cave, Running Bull Cave, and Thunderhole Resurgence, and incorporates an area of approximately 48.34 km\2\ (18.67 mi\2\). Mystery Cave includes Mystery Resurgence, Mystery Overflow Spring, Maple Leaf Cave, and Miller Spring, and the total area of its recharge area is approximately 18.26 km\2\ (7.05 mi\2\) (Moss and Pobst 2010, p. 154). The recharge area of Rimstone River Cave covers 24.53 km\2\ (9.47 mi\2\), and the main features within it include Lost Creek Cave, Weinrich Onyx Cave, Onyx Annex Cave, Twin Cave, and Snow Caverns (Moss and Pobst 2010, p. 158). The recharge area for Running Bull Cave extends from Maple Leaf Cave to Thunderhole Resurgence and encompasses 2.74 km\2\ (1.06 mi\2\) (Moss and Pobst 2010, p. 159). Thunderhole Resurgence receives water from multiple sources and, during high water events, some of the caves mentioned previously can contribute water to this resurgence (Moss and Pobst 2010, pp. 154, 159-160). Under high flow conditions, the Mystery Cave groundwater system overflows to Thunderhole Resurgence (Moss and Pobst 2010, p. 160). The total base flow recharge area of Thunderhole Resurgence is approximately 5.57 km\2\ (2.15 mi\2\).

Unit 3: Blue Spring Branch, Perry County, Missouri: Unit 3 includes approximately 6.4 km (4.0 mi) of the surface portions of Blue Spring Branch from points downstream of the Moore Cave System to its confluence with Bois Brule Creek (Burr et al. 2002, pp. 280-281; Moss and Pobst 2010, pp. 147, 183). Blue Spring Branch is the principal resurgence stream for caves identified above within the Moore Cave System (Burr et al. 2001, p. 284).

Unit 4: Cinque Hommes Creek, Perry County, Missouri: Unit 4 includes approximately 24.4 km (15.2 mi) of Cinque Hommes Creek that generally flows in a northeast direction from near Interstate 55 south-southeast of Perryville to its confluence with Bois Brule Creek (Adams 2005, p. 90; Burr et al. 2001, p. 281).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs for Cottus specus consists of seven components Nevada are be the following (78 FR 58923-58938):

(1) Geomorphically stable stream bottoms and banks (stable horizontal dimension and vertical profile) with riffles, runs, pools, and transition zones between these stream features.

(2) Instream flow regime with an average daily discharge between 0.07 and 150 cubic feet per second (cfs), inclusive of surface runoff, cave streams, resurgences, springs, and occupied surface streams and all interconnected karst areas with flowing water.

(3) Water temperature between 12.8 and 16.7 °C (55 and 62 °F), dissolved oxygen 4.5 milligrams or greater per liter, and turbidity of an average monthly reading of no more than 200 Nephelometric Turbidity Units for a duration not to exceed 4 hours.

(4) Adequate water quality characterized by low levels of contaminants. Adequate water quality is defined as the quality necessary for normal behavior, growth, and viability of all life stages of the grotto sculpin.

(5) Bottom substrates consisting of a mixture of sand, gravel, pebble, cobble, solid bedrock, larger cobble and rocks for cover, with low amounts of sediments.

(6) Abundance of aquatic invertebrate prey base to support the different life stages of the grotto sculpin.

(7) Connected underground and surface aquatic habitats that provide for all life stages of the grotto sculpin, with sufficient water levels to facilitate movement of individuals among habitats.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features that are essential to the conservation of the species and may require special management considerations or protection. The features essential to the conservation of grotto sculpin center around attributes that highlight the importance of water quality within the karst recharge areas of occupied cave streams, resurgences, and surface streams. Special management considerations or protection are required within occupied habitats to address these threats. Management activities that could ameliorate these threats include (but are not limited to) actions that: (1) Minimize potential adverse effects from contaminants originating from sinkholes where trash, debris, chemical containers, or animal carcasses have been deposited; (2) reduce soil erosion and silt deposition; (3) reduce storm runoff of potentially harmful agricultural pesticides, various oil pollutants, and other sources of water soluble contaminants; (4) implement best management practices to minimize possible contamination from septic systems; (5) provide recommendations that improve the efficiency and efficacy of vertical drains; (6) place and manage vegetative buffers around vertical drains designed to reduce soil erosion, reduce water flow, and improve the quality of water runoff; (7) implement best management practices to minimize potential impacts from residential, commercial, industrial and agricultural development; (8) provide recommendations that significantly reduce sources of nitrification and fecal coliform and coliform bacteria originating from domestic livestock; (9) implement best management practices that enhance surface stream and riparian corridor stability; (10) enforce existing Federal and State regulations that are in place to maintain high water quality standards; (11) minimize, enhance, and conserve water levels of underground aquifers, cave streams, resurgences, springs, and surface streams; and (12) provide technical assistance through public outreach and education (78 FR 58923-58938).

Life History

Feeding Narrative

Juvenile: Juveniles tend to congregate in resurgence areas (springs). Analyses of two grotto sculpin populations by Gerken and Adams (2007) showed that sculpins in surface waters disproportionately used shallower areas with high abundance of prey items. (NatureServe, 2015)

Adult: Adults tend to inhabit caves where food items likely include amphipods, isopods, crayfish, and small fishes. Adults often cannibalize small juveniles. (NatureServe, 2015)

Reproduction Narrative

Adult: The appearance of grotto sculpin young-of-year in spring and early summer suggests late winter and early spring spawning (Day 2008). Nests have been observed in resurgent areas (where cave streams reach the surface) and very close to cave portals as well as interior in caves. Five nests, with approximately 200 eggs each, were discovered within 100 meters, suggesting synchronous spawning within the cave (Adams 2005). Nests were adhered to the underside of rocks in flowing water with a temperature of 14 ?C; temperatures. Reproduction likely occurs as late as February or March based on the observation of yolksac larvae and a single nest (Adams et al, unpub data). Spawning could be tied to water temperature, with temperatures reaching optimum levels in caves as early as 2 to 3 months before surface habitats (Adams 2005). Males remain present at nests and guard rocks to which nests are attached (Adams et al. unpub. data). (USFWS 2012) Additional surveys conducted between December 2016 and March 2017 examined nest site habitat characteristics and found a preference for firm substrate (cobble and bedrock with a mean firmness of 1.13 cm) in moderately flowing, shallow streams with a mean velocity of 0.102 m/s and mean depth of 15.25 cm, relative to random sites. Interestingly, nest sites were found progressively upstream as the spawning period progressed, possibly due to increased agitation and thus higher oxygen availability in shallower waters there (Fernholz et al. 2019) (USFWS, 2021).

Spatial Arrangements of the Population

Adult: Variable (Inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow/specialist (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (Inferred from NatureServe, 2015)

Habitat Narrative

Adult: This sculpin inhabits cave systems in karst areas, occupying pools and riffles with moderate stream flow and low to moderate stream depth (see USFWS 2002). Individuals occur in open water or hidden under rocks in a variety of substrates including silt, gravel, cobble, rock rubble that originated from cave breakdown material, or solid bedrock. Uniquely formed cave systems may be the only habitats that provide enough food (these caves provide an abundance of invertebrates) and sustained water flow for the species (Burr et al. 2001). Johnson et al.

(2008) reported that grotto sculpins are "believed to transition between cave and surface streams throughout their lifetime." Johnson et al. (2008) found large numbers of young-of-year fish in surface sites from spring through fall (May-October). Then the sculpins disappeared, presumably into the nearby caves. Growth constants for the young were found to be up to twice as high in surface streams as in cave streams. The authors concluded that grotto sculpins were using these resurgence sites as nursery areas that allowed young fish "to grow quickly before entering into the caves, minimizing chances for cannibalism by larger sculpins after migration underground. Analyses of two grotto sculpin populations by Gerken and Adams (2007) showed that sculpins in surface waters disproportionately used shallower areas with high abundance of prey items, whereas sculpin habitat use in caves was best explained by depth, with sculpins favoring deeper habitats. (NatureServe, 2015) Overall, adult Grotto Sculpin were most abundant in pools, or areas of the stream characterized by relatively deep depths and a slow current; this finding was regardless of which cave was sampled. However, juvenile sculpin in Tom Moore Cave were more abundant in riffles, or areas of the stream often agitated by rocks and characterized by relatively shallow depths and a quick current. Analysis revealed depth and substrate as the most important factors for modeling habitat use in Running Bull Cave and Tom Moore Cave, while depth was the most important factor in Mystery Cave. Pools featuring slow velocity and cobble substrate were selected for most. (USFWS, 2021)

Dispersal/Migration

Motility/Mobility

Adult: Low (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Migratory (NatureServe, 2015)

Dispersal

Adult: Low (NatureServe, 2015)

Immigration/Emigration

Adult: No (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Based on mark-recapture studies, Day et al. (2008) concluded that the relatively sedentary nature of the grotto sculpin may limit its ability to recolonize habitats. Adams et al. (2008) found that the majority (68%) of recaptured grotto sculpins moved 0-50 meters, which is typical of many benthic species. However, substantial migrations were seen and may have been related to spawning. Johnson et al. (2008) reported that grotto sculpins are "believed to transition between cave and surface streams throughout their lifetime." Johnson et al. (2008) found large numbers of young-of-year fish in surface sites from spring through fall (May-October). Then the sculpins disappeared, presumably into the nearby caves. Growth constants for the young were found to be up to twice as high in surface streams as in cave streams. The authors concluded that grotto sculpins were using these resurgence sites as nursery areas that allowed young fish "to grow quickly before entering into the caves, minimizing chances for cannibalism by larger sculpins after migration underground." (NatureServe, 2015)

Population Information and Trends

Population Trends:

As of May, 2021, no total population estimates or general population trends have been calculated for the entirety of the Grotto Sculpin range (USFWS, 2021).

Resiliency:

Using the strategy outlined (Table 8), we ranked each factor per analysis unit (Table 9). To calculate overall resiliency per unit, we used the weighted mean of resiliency factors for each analysis unit where abundance was weighted the highest (5), water quality the second highest (4), food availability the third highest (3), habitat availability and connectivity the fourth highest (2), and genetic diversity the lowest (1). For the Crevice and Rimstone River units, which had unknown abundance, we calculated what overall resiliency would be under all abundance scenarios and determined that for both units, if abundance is high or moderate, overall resiliency would be moderate, and if abundance is low, overall resiliency would be low. Overall resiliency was moderate for the other units (Figure 17). Again, resiliency refers to the ability of populations to withstand stochastic events, i.e., the natural range of favorable and unfavorable conditions. For this SSA, empirical data are not available to associate resiliency rankings with specific quantitative extinction risks or probabilities of persistence, although we provide very rough estimations of probabilities of persistence (Table 8). Rather, we are limited to providing qualitative definitions of each resiliency rank. Populations with lower resiliency are highly vulnerable to stochastic events and face a high risk of extirpation within the next few decades. Populations with moderate resiliency are less likely to be extirpated within the next few decades but require additional growth (with help from regular habitat management and/or restoration) to become more self-sustaining and resilient to stochastic events. Populations with higher resiliency are unlikely to be extirpated within the next few decades in the absence of catastrophes or significant declines in the quality of habitat management (USFWS, 2023).

Representation:

Representation reflects the ability of a species to cope with or adjust to near- and long-term changes in its physical and biological environments. A species' adaptive potential, or capacity, is characterized by the local ecological conditions that influence where it can occur, and can be assessed by evaluating intraspecific genetic, ecological, morphological, and/or behavioral variability. Recent investigations reveal significant morphological, genetic, and ecological diversity exhibited by populations of grotto sculpin across their endemic range (MDC 2021, pers. comm.), suggesting a relatively high level of diversity for such a range-restricted species. We defined two representative units based on the two distinct genetic lineages of grotto sculpin that exist north and south of Cinque Hommes Creek (Figure 3). The Southern Unit (Mystery, Rimstone River, and Running Bull) appears to be more genetically diverse and to have greater connectivity between surface and cave populations than the Northern Unit (Moore and Crevice) (USFWS, 2023).

Redundancy:

Redundancy describes the ability of a species to withstand catastrophic events by maintaining multiple, resilient populations across the species' geographic range. The grotto sculpin always has had few populations in a limited geographic range (one county in Missouri). Furthermore, none of those populations (analysis units) are currently ranked high in overall resiliency. Thus, any catastrophic event would likely impact the species across the entirety of its endemic range. The level of redundancy for the grotto sculpin is inherently limited and is further decreased by the reduced resiliency of the populations (USFWS, 2023).

Population Growth Rate:
Unknown (NatureServe, 2015)

Number of Populations:
Six recharge zones (USFWS, 2023).

Population Size:
As of May, 2021, no total population estimates or general population trends have been calculated for the entirety of the Grotto Sculpin range (USFWS, 2021).

Adaptability:
Low (inferred from NatureServe, 2015)

Additional Population-level Information:
We used recharge area delineations presented in Moss (2013, pp. 179–180) as the basis for delineating populations (i.e., analysis units) of grotto sculpin. Ball Mill Springs recharge area was excluded, as water in this recharge area drains to the east away from the Moore cave system into Ball Mill and not Blue Springs (Mark Brooks, pers. comm. Nov 2022). Therefore, the water in this recharge area does not have any significant influence on the grotto sculpin either below or above ground. Additionally, Cinque Hommes Creek was designated as an analysis unit due to populations of sculpin within this stream (Adams et al. 2013, p. 485). The six analysis units generally conform to the known water recharge zones of the associated mapped cave systems (USFWS, 2023).

Population Narrative:
Only a few thousand individuals are thought to exist (Burr et al. 2001, USFWS 2009). In determining the overall distribution, Burr et al. (2001) sampled over 27 cave streams within six karst regions in Perry County and documented the species in only five cave systems (Crevice, Moore, Mystery, Rimstone River, and Running Bull/Mapleleaf). To date, over 153 additional caves in Arkansas, Illinois, Indiana, Missouri, and Tennessee have been searched for Grotto sculpin and epigean or hypogean forms of banded sculpin. Of these, the banded sculpin was documented in 25 caves, but only fish in the 5 caves listed above exhibited the cave adaptations reported for grotto sculpin (Burr et al. 2001). (NatureServe, 2015). As of May, 2021, no total population estimates or general population trends have been calculated for the entirety of the Grotto Sculpin range (USFWS, 2021).

Threats and Stressors

Stressor: Chemical contamination (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Threats include water contamination as a result of point and nonpoint pollution from urban and agricultural sources (Burr et al. 2001, USFWS 2009). A large die-off of Grotto sculpins in one of the five known occupied cave systems was likely a result of pollution (USFWS 2009). Burr et al. (2001) reported that more than half of the sinkholes in Perry County contain

anthropogenic refuse, ranging from household cleansers and sewage to used pesticide and herbicide containers. These potential predators on grotto sculpin may escape surface farm ponds that unexpectedly drain through sinkholes into the underground cave systems and enter grotto sculpin habitat (USFWS 2009). (NatureServe, 2015)

Stressor: Animal carcasses (USFWS, 2013a)
Exposure:
Response:
Consequence:
Narrative: Sinkholes have been used as disposal sites for dead livestock (Fox et al. 2009; Moss and Pobst 2010). Animal carcasses dumped into sinkholes and cave entrances are potentially diseased and could carry pathogens that could be unintentionally introduced into the groundwater system. Decomposing animals in source water for cave streams also can lower the dissolved oxygen and negatively impact aquatic organisms. (USFWS, 2012)

Stressor: Urbanization and development. (USFWS, 2013a)
Exposure:
Response:
Consequence:
Narrative: The water quality of sculpin habitats is negatively impacted by urban growth of Perryville, located in the recharge area for Crevice Cave (Moss and Pobst 2010). Hazardous waste facilities are in Perryville along with nine underground storage tanks that could leak petroleum products. Perryville also has National Pollutant Discharge Elimination System (NPDES) permits for wastewater outfalls and stormwater discharge, leaking or uncapped sewer lines (Missouri Department of Natural Resources, 2010) and inadequate septic systems (Aley 2012, pers. comm.) which easily drain wastewater through karst systems (Simon and Buikema 1997; Panno et al. 2006). (USFWS, 2013a)

Stressor: Sediment and siltation (USFWS, 2013a)
Exposure:
Response:
Consequence:
Narrative: Soils in the karst areas are dominated by highly erosive loess. Sediment transported into the karst groundwater can include agricultural chemicals that are bound to soil particles; the turbidity of streams in grotto sculpin caves in Perry County was positively correlated with total chemical and DEA concentrations (Fox, 2010). Additionally, Gerken and Adams (2007, p. 76) noted that siltation was a major problem in grotto sculpin sites and postulated that silt likely reduced habitat available to this fish by changing the overall structure of the habitat (Berkman and Rabeni 1986). Silt can fill voids in rock substrate that are integral components of habitat for reproduction and predator avoidance. The grotto sculpin occurs in habitats with some level of sediment deposition (Gerken 2007). However, siltation beyond what occurred historically could limit the amount of suitable habitat available (Gerken 2007; Gerken and Adams 2007). (USFWS 2013a)

Stressor: Sand mining (USFWS 2013a)
Exposure:
Response:
Consequence:

Narrative: Mining for silica sand in Missouri occurs in the St. Peter sandstone (USGS 2011) which is directly adjacent to formation that forms the karst habitat for the grotto sculpin in Perry County. The existing operation involves open pit mining on 101 ha (250 acres) (USGS 2010) at the western edge of the sinkhole plain with approximately four sinkholes occurring in the immediate vicinity. Erosion of soil and disturbed overburden could occur and increase the sediment loads in adjacent surface waters and cave streams via runoff. Sand mining is considered a potentially significant threat to the species in the future. (USFWS, 2013a)

Stressor: Predation (USFWS 2013a)
Exposure:
Response:
Consequence:
Narrative: Predation by invasive, epigean fish poses a threat to eggs, young-of-year, and juvenile grotto sculpin. Farm ponds are often stocked with both native and nonnative fishes for recreational purposes. These fish enter cave systems through sinkholes when ponds are unexpectedly drained (Burr et al. 2001) or after high-precipitation events. A variety of predatory fish have been documented in all of the caves occupied by the grotto sculpin (Burr et al. 2001). The migration and persistence of invasive, epigean fish species into cave environments poses an ongoing and pervasive threat to the grotto sculpin. (USFWS 2013a) Predatory fish, including Green Sunfish (Lepomis cyanellus), Golden Shiner (Notemigonus crysoleucas), Largemouth Bass (Micropterus salmoides), Bluegill (Lepomis macrochirus), Longear Sunfish (Lepomis megalotis), and Yellow Bullhead (Ameirus natalis) have been documented in caves occupied by Grotto Sculpin as recently as 2017, with high prevalence noted in Crevice Cave (Fenholtz et al. 2019). (USFWS, 2021).

Stressor: Degradation of aquatic resources (USFWS, 2013a)
Exposure:
Response:
Consequence:
Narrative: The primary threats to the grotto sculpin are degradation of aquatic resources from illegal waste disposal in sinkhole dumps, pesticide runoff, chemical leaching, urban development, and sedimentation. Existing Federal, State, and local laws have not been able to prevent impacts to the grotto sculpin and its habitat largely because of noncompliance and inability to fully enforce existing laws (USFWS, 2013). Sinkholes and natural cave openings in Perry County are routinely filled with trash, concreted, bulldozed, converted into ponds, obliterated by urbanization, or most commonly, converted to agricultural drains through the installation of standpipes in Perry County (Scott House, pers. comm. 2021). All of these manmade closures and obstructions reduce natural flows of organic matter into the Grotto Sculpin's habitat, thereby constricting the nutrient basis of food webs upon which the species depends. (USFWS, 2021).

Stressor: parasitic infections (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: Additional research indicates water degradation may also increase Grotto Sculpin susceptibility to parasitic infections due to increased stress and reduced health. This may be compounded by a lack of prey items in highly polluted areas and a concomitant increased reliance on cannibalism among Grotto Sculpin for sustenance (Day et al. 2014; Day et al. 2016)

(USFWS, 2021).

Stressor: Climate change (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Global climate change has the potential to affect biodiversity with stressors driven by increasing temperatures and extreme climatic events (Settele et al. 2014, pp. 294–301). Over the last 115 years, the global average surface air temperature has increased by 1.0°C (1.8°F) with recent decades being the warmest in approximately 1,500 years (Vose et al. 2017, pp. 186, 188). In the contiguous U.S., annual average temperature is projected to increase up to 1.4°C (2.4°F) during the mid-21st century relative to 1976–2005 (Vose et al. 2017, p. 185). Within the Midwest and Southeastern United States, there has been an overall increase in temperature and extreme precipitation since 1901 (USGCRP 2017, pp. 20, 187). During this time, annual average temperature in these regions has increased by 0.26 to 0.70°C (0.46 to 1.26° F)1 (USGCRP 2017, p. 187). Since 1901, annual precipitation has increased by up to 10%2 , and maximum daily precipitation has increased 18%3 (USFWS, 2023).

Stressor: Indirect Human Disturbance (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Many groups venture into caves for personal and professional activities, including cave biologists, archaeologists, geologists, cave explorers, cave mappers, and others. While traversing cave environments, there is the potential that grotto sculpin eggs, resting under substrate are crushed or dislodged when cavers walk through shallow underground streams (Vona Kuczynska 2021, pers. comm.; Van Beynen and Townsend 2005, p. 108). Caves can be disturbed by enlarging passages or creating new entrances to facilitate tourism, which can lead to habitat removal and change in air flow that will impact the cave environment (Van Beynen and Townsend 2005, p. 108). The extent to which humans walking through streams has degraded grotto sculpin cave habitat or resulted in the lethal take of sculpin individuals or eggs has not been quantitively measured and is therefore unknown (USFWS, 2023).

Stressor: Invasive Alien Species (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: One factor influencing water quantity is the presence of invasive plant species (Corbin and D'Antonio 2012, p. 120). Invasive plans can alter the physical structure of soil, increasing soil erosion rates and rates of soil accumulation, influencing water table depth and stream channel structure (Corbin and D'Antonio 2012, p. 120). For example, surface runoff has the potential to increase if the presence of an invasive plant permits greater exposure of bare ground (Corbin and D'Antonio 2012, p. 120). Conversely, an increase in soil retention due to invasive plants could reduce the width of surface water streams, reducing water flow capacity, and has the potential to change surface topography (Corbin and D'Antonio 2012, p. 120). Garlic mustard (Alliaria petiolate), Japanese stiltgrass (Microstegium vimineum), Japanese hop (Humulus japonicus), Japanese honeysuckle (Lonicera japonica), and mimosa (Albizia julibrissin) have been observed within a 20-mile radius of Perryville (EDDMapS 2021, unpaginated). These invasive alien

terrestrial plants compete with native plants for available moisture, increase the risk of contaminant leakage from subterranean pipes and containers damaged by the species' roots, reduce native species diversity, alter habitat structure and soil chemistry, and increase fire risk (USFWS, 2023).

Recovery

Recovery Actions:

- There is no Recovery Plan for the species.
-

Conservation Measures and Best Management Practices:

- Recommendations for future conservation actions: • Work with and support partners in gaining an understanding of demographic features of Grotto Sculpin and ecological features of their habitat to aid in informing the development and implementation of a recovery plan. Researchers have indicated passive integrated transponder (PIT) tags may be safely applied to Banded Sculpin and therefore offer a feasible method of non-lethal monitoring to assess population characteristics of small fish species. Accordingly, PIT tag use in Grotto Sculpin could lead to insights into growth, recruitment, and mortality, as well as other characteristics essential for the conservation of the species (Fernholz and Phelps 2016). Research regarding the role of bats on the ecology of caves inhabited by Grotto Sculpin may also reveal ecological features vital to the species' recovery and delisting. • Develop a draft and final recovery plan for the Grotto Sculpin. The recovery plan should include objective, measurable delisting criteria. Recovery criteria should address all known threats meaningfully impacting the species, and should estimate the time required as well as the cost to carry out those measures needed to achieve the goal for recovery and delisting. • Collaborate with MDC and other partners on the identification and implementation of priority land acquisitions, easements and/or cave entrance protection measures, as well as population monitoring, point and non-point pollution source inventories and vulnerability mapping of known recharge zones with viable Grotto Sculpin populations. • Support the engagement of Federal, State, local, tribal, and private partners in Grotto Sculpin recovery.

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USFWS. 2023. Grotto sculpin (Cottus specus) Species Status Assessment. Version 1.0., 2023. Bloomington, MN. pp. 74 + appendices.

SPECIES ACCOUNT: *Crenichthys baileyi baileyi* (White River springfish)

Species Taxonomic and Listing Information

Listing Status: Endangered, September 27, 1985 (50 FR 39123).

Physical Description

The White River springfish lacks pelvic fins, and the dorsal and anal fins are placed far back on the body. Body coloration is typically dark olive above and silvery white below, with bright silver on the cheek and opercle. There are two rows of dark spots or bands along the side of the body. Breeding males exhibit more intense coloration than females, with mid-dorsal markings becoming very dark and contrasting with light, sometimes yellow sides. The White River springfish is moderate in size compared to the other subspecies. Average adult size is <35 millimeters [mm] (1.4 inches [in.]) (USFWS 2012).

Taxonomy

There are five subspecies of C. baileyi taxonomy. The subspecies are distinguished based on significant morphological differences among populations from isolated springs along the White River in Nevada. The White River springfish are small, and have two rows of dark spots along the side of the body, as opposed to the single row or band found on the Railroad Valley springfish (USFWS 2012).

Historical Range

The White River springfish is endemic to thermal pools and outflows created by Ash Springs in Pahranagat Valley, Lincoln County, Nevada. Historically, the distribution of White River springfish in the outflow of Ash Springs was as far downstream as 8 to 11 kilometers (5 to 7 miles) north of the town of Alamo. Much of this outflow stream is commonly referred to as the Pahranagat Creek or Pahranagat Ditch (USFWS 2012).

Current Range

Currently, White River springfish in the Ash Springs system occur primarily in the spring pools and outflow above US 93, and in limited numbers in the outflow below US 93 to the confluence with Pahranagat Creek. The majority of the fish's distribution is on private property, with only 5 percent being on land administered by the Bureau of Land Management (USFWS 2012).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/27/1985.

Legal Description

On September 27, 1985 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Crenichthys baileyi baileyi (White River springfish) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Nevada (50 FR 39123-39126).
The critical habitat designation for Crenichthys baileyi baileyi includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary

constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Crenichthys baileyi baileyi.

Critical Habitat Designation

The critical habitat designation for Crenichthys baileyi baileyi includes one CHU in Lincoln County, Nevada (50 FR 39123-39126).

(1) Nevada, Lincoln County. Ash Springs and associated outflows plus surrounding land areas for a distance of 50 feet from the springs and outflows within the following areas: T6S, R60E. E1/2 of E1/2 Sec. 1 and T6S, R61E, NW1/4 of NW1/4 Sec. 6.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (50 FR 39123-39126):

(1) warmwater springs and their outflows and surrounding land areas that provide vegetation for cover and habitat for insects and other invertebrates on which the species feeds.

Special Management Considerations or Protections

The Nevada State Division of Historical Preservation and Archaeology requested that it be permitted to comment on any management activities that might disturb land surrounding spring habitats. The Service has planned no management activities that might disturb land surrounding spring habitats. Should any such activities be planned in the future, the Service will make the proper notifications.

Life History

Feeding Narrative

Juvenile: See narrative for adult.

Adult: The White River springfish feeds opportunistically; it has an omnivorous diet that may include food such as diatoms, algae, plant parts, detritus, and macroinvertebrates (NatureServe 2015). Food resource distribution is widespread, and they have a high bioenergetic requirement. Competition occurs between the nonnative convict cichlid and the White River springfish (USFWS 1998).

Reproduction Narrative

Adult: Sexual maturity of White River springfish is reached when the female is between 24 and 28 mm (0.9 and 1.1 in.) in length; however, populations in environments with exotic aquatic species tend to have females that are smaller at first maturity. Most springfish females appear to spawn twice annually. Spawning occurs throughout the year and is asynchronous, but there may be a peak in spawning during the warm summer months (USFWS 1998). The number of eggs deposited per spawning event is approximately 3 to 17. This species is a broadcast spawner, releasing eggs and sperm into open water for external fertilization. Eggs are adhesive and attach firmly to nearby vegetation. There is no subsequent parental care. The lifespan is approximately 3 to 4 years (USFWS 2012).

Geographic or Habitat Restraints or Barriers

Juvenile: Historically, the spring pool population has been separated from the outflow stream population by steep topography.

Adult: Historically, the spring pool population has been separated from the outflow stream population by steep topography (USFWS 1998).

Spatial Arrangements of the Population

Juvenile: White River springfish exist primarily in the spring pools and outflow of Ash Springs.

Adult: White River springfish exist primarily in the spring pools and outflow of Ash Springs.

Environmental Specificity

Juvenile: Narrow

Adult: Narrow

Tolerance Ranges/Thresholds

Juvenile: Low

Adult: Low

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Juvenile: No

Adult: No

Habitat Narrative

Juvenile: See narrative for adult.

Adult: The White River springfish occurs in warm water springs and their outflows, in temperatures ranging from 33 °C (91.4 °F) at the outflow to 35° C (95 °F) at the headpool of Ash Springs (NatureServe 2015). Historically, the spring pool population has been separated from the outflow stream population by steep topography (USFWS 1998). The species requires vegetation cover surrounding the springs for cover and habitat for invertebrate species on which it feeds (50 FR 39123). The species has a low tolerance/threshold and high site fidelity. Adults are found at varying depths, from 0.4 to 1.7 m (1.3 to 5.6 ft.), but they prefer deeper water (USFWS 1998).

Dispersal/Migration

Motility/Mobility

Juvenile: Limited

Adult: Limited

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Nonmigratory

Adult: Nonmigratory

Dispersal

Juvenile: Low

Adult: Low

Immigration/Emigration

Juvenile: Not likely.

Adult: Not likely.

Dependency on Other Individuals or Species for Dispersal

Juvenile: No

Adult: No

Dispersal/Migration Narrative

Juvenile: White River springfish are endemic to Ash Springs in the Pahranagat Valley. The springs have a common outflow stream, which has been impounded by construction of US 93 and now forms a large pool. Below the highway, the outflow stream flows southwest to join the outflow stream from Crystal Spring. Occasionally there may be some migration of Hiko White River springfish in the outflow stream of Ash Springs during large flood events (USFWS 2012).

Adult: The White River springfish is nonmigratory and has limited mobility within its narrow range. Dispersal is low, and immigration is unlikely (NatureServe 2015).

Additional Life History Information

Juvenile: No

Population Information and Trends

Population Trends:

Stable

Species Trends:

Stable but depressed populations.

Number of Populations:

One (USFWS, 2022)

Population Size:

The most recent survey was conducted in August 2018, which resulted in a count of 2,060 individuals (USFWS, 2022)

Adaptability:

Low

Population Narrative:

Populations of the White River springfish are depressed but appear stable. Stress from competition and predation of invasive species is the largest threat to the subspecies. The White River springfish remains at risk of extinction because of its restricted range, depressed population, and ongoing threats (USFWS 2012).

Threats and Stressors

Stressor: Competition/predation
Exposure: Pressure on available resources, direct pressure on White River springfish.
Response: Decrease in fish size and populations.
Consequence: Introduced species compete for available resources with the White River springfish and increase predation pressure (USFWS 2012).
Narrative: Competition and/or predation by introduced species put increased pressure on available resources and direct pressure on the White River springfish. This may cause a decrease in fish size and reduced population size. Introduced species compete for available resources with the White River springfish and increase predation pressure (USFWS 2012).

Stressor: Parasites
Exposure: Infestations of parasites from introduced species.
Response: May result in negative impacts to White River springfish.
Consequence: Disease or parasites introduced from exotic aquaria fishes may reduce viability of springfish. These parasites are not known to occur naturally in native fish populations, and likely result in negative impacts (USFWS 2012).
Narrative: Introduced species may harbor parasites that become introduced into the ecosystem, possibly resulting in negative impacts to the White River springfish (USFWS 2012).

Stressor: Recreational use of Ash Springs pools
Exposure: Affects bank stability, shoreline vegetation, and water quality.
Response: Diminishes habitat quality.
Consequence: Recreational use on public land threatens White River springfish habitat (USFWS 2012).
Narrative: Recreational use of Ash Springs pools may affect bank stability, shoreline vegetation, and water quality. This may contribute to diminished habitat quality and threaten the existence of the White River springfish (USFWS 2012).

Recovery

Reclassification Criteria:

Need to develop reclassification criteria.

Recovery Priority Number: 3C

Delisting Criteria:
A self-sustaining population (comprising three or more age classes, a stable or increasing population size, and documented reproduction and recruitment) is present in the spring pool of Ash Spring for three generations (or a minimum of six consecutive years) (USFWS 1998).

Impacts to the species and its habitats have been reduced or modified to a point where they no longer represent a threat of extinction or irreversible population decline (USFWS 1998).

Recovery Actions:
- Maintain and enhance aquatic and riparian habitats in Pahranagat Valley (USFWS 1998).
- Develop and implement monitoring plans (USFWS 1998).
- Provide public information and education (USFWS 1998).
- Establish and maintain populations at Dexter National Fish Hatchery, Key Pittman Wildlife Management Area, and Pahranagat National Wildlife Refuge (USFWS 1998).
- Enhance aquatic and riparian habitats in the Pahranagat Valley (USFWS 1998).
- Develop and implement habitat enhancement plans for the Pahranagat Valley (USFWS 1998).
- Establish and maintain refugia populations (USFWS 1998).

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS • Continue working with private landowners to foster positive working relationships and develop conservation agreements that facilitate recovery actions to improve the springpool habitat of Crystal and Hiko Springs. Habitat improvement projects may include efforts to eradicate nonnative aquatic species, nonnative vegetation removal/treatment, and changes in agricultural management. • Continue nonnative species control and eradication. Regularly analyze the effectiveness of removal efforts and adapt to new methods as they are identified. • Reevaluate taxonomy as new information becomes available (USFWS, 2022).

Additional Threshold Information:
-
-

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See juvenile life stage.

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USFWS. 2022. 5-YEAR REVIEW Hiko White River Springfish (Crenichthys baileyi grandis) and White River Springfish (Crenichthys baileyi baileyi). 11 pp.

SPECIES ACCOUNT: *Crenichthys baileyi grandis* (Hiko White River springfish)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; September 27, 1985; Region 8 - Nevada (NatureServe 2015)

Physical Description

The Hiko White River springfish (C. baileyi grandis) is the largest of five subspecies. White river springfish (C. baileyi) are small, deep-bodied fish that are generally olivaceous dorso-laterally and silver ventrally, with two lateral rows of dark spots on the sides. The Hiko White River springfish is the largest of five subspecies. Adults average >40 millimeters (mm) (1.6 inches [in.]) and can exceed 65 mm (2.6 in.) (USFWS 2012). Breeding males display a brilliant lemon yellow color on the ventral surface of the head and body that sometimes turns into a deep orange color on the caudal fin.

Taxonomy

The Hiko White River springfish is a subspecies of the White River springfish. Taxonomy includes five subspecies based on significant morphological differences among populations from isolated springs along the White River in Nevada. The Hiko White River springfish differ from the other subspecies by their larger size and deeper coloration. They have longer heads than Preston White River springfish and more dorsal and anal fin rays than Moorman White River springfish and Ash Springs White River springfish.

Historical Range

The Hiko White River springfish is historically restricted to the thermal pools and outflows of Hiko and Crystal springs, two large thermal springs discharging on the valley floor of Pahranagat Valley north of the town of Alamo on the White River in Nevada.

Current Range

Currently this subspecies occupies Crystal and Hiko springs of the White River. In 1967, the subspecies was extirpated from Hiko Spring; it was later reintroduced. A refugium population exists in Blue Link Spring far outside the native range.

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/27/1985.

Legal Description

On September 27, 1985 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Crenichthys baileyi grandis (Hiko White River springfish) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two critical habitat units (CHUs) in Nevada (50 FR 39123-39126).

The critical habitat designation for Crenichthys baileyi grandis includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Crenichthys baileyi grandis.

Critical Habitat Designation

The critical habitat designation for Crenichthys baileyi grandis includes two CHUs in Lincoln County, Nevada (50 FR 39123-39126).

(1) Nevada, Lincoln County. The following springs and outflows plus surrounding land areas for a distance of 50 feet from these springs and outflows: Hiko Spring and associated outflows within T4S, R60E SW1/4 of NE1/4 Sec. 14 and NW1/4 of SE1/4 Sec. 14.

(2) Nevada, Lincoln County. The following springs and outflows plus surrounding land areas for a distance of 50 feet from these springs and outflows: Crystal Springs and associated outflows within T5S, R60E, all of NE1/4 of Sec. 10 and NE1/4 of SE1/4 Sec. 10. SW1/4 of NW1/4 Sec. 11 and NW1/4 of SW1/4 Sec. 11.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (50 FR 39123-39126):

(1) warmwater springs and their outflows and surrounding land areas that provide vegetation for cover and habitat for insects and other invertebrates on which the species feeds.

Special Management Considerations or Protections

The Nevada State Division of Historical Preservation and Archaeology requested that it be permitted to comment on any management activities that might disturb land surrounding spring habitats. The Service has planned no management activities that might disturb land surrounding spring habitats. Should any such activities be planned in the future, the Service will make the proper notifications.

Life History

Feeding Narrative

Adult: The Hiko White River springfish consumes invertebrates, filamentous algae, vascular plants, and diatoms.

Reproduction Narrative

Adult: Most Hiko White River springfish females appear to spawn twice annually. Spawning occurs throughout the year and is asynchronous, but there may be a peak in spawning during the warm summer months. Approximately 6 to 17 eggs are deposited per spawning event. This species is a broadcast spawner, releasing eggs and sperm into open water for external fertilization. Eggs are adhesive and attach firmly to nearby vegetation. There is no subsequent parental care.

Geographic or Habitat Restraints or Barriers

Adult: Surface water impoundment, outflow streams captured in underground pipes.

Spatial Arrangements of the Population

Adult: The Hiko White River springfish is confined to impounded pools at Hiko Spring, Crystal Spring, and Blue Link Spring. It is found at varying depths, from 0.4 to 1.7 meters (1.3 to 5.6 feet), but prefer deeper water.

Environmental Specificity

Adult: Narrow

Tolerance Ranges/Thresholds

Adult: Can inhabit water of high temperatures, 26 to 37 degrees Celsius (79 to 99 degrees Fahrenheit), and low dissolved oxygen.

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: None

Habitat Narrative

Adult: The Hiko White River springfish requires warm water springs, including outflows and surrounding land areas, that provide vegetation for cover and habitat for insects and other invertebrates on which the species feeds.

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low

Immigration/Emigration

Adult: No

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: The Hiko White River springfish is a nonmigratory species, confined to impounded pools at Hiko, Crystal, and Blue Link springs of the White River in Nevada.

Additional Life History Information

Adult: Not applicable.

Population Information and Trends

Population Trends:
Declining

Species Trends:
Declining

Population Growth Rate:
Populations are persisting but at low numbers in most locations. The refuge at Blue Link Spring continues to show high population numbers.

Number of Populations:
3 (USFWS, 2022)

Population Size:
a. Hiko Spring – The population at Hiko Spring has remained suppressed since the early 2000s (Figure 1). This coincides with the establishment of red swamp crayfish (Procambarus clarkii) at Hiko Spring. Prior to the invasion of crayfish, the population was larger and more stable with population estimates typically exceeding 2,000 individuals. In 2020, NDOW conducted a mark-recapture survey that estimated 310 individuals with a 95% confidence interval of 113 to 775 individuals (NDOW 2020a). b. Crystal Springs – The population at Crystal Springs has increased since the removal of convict cichlid (Amatitlania nigrofasciata) from the springheads. This removal effort is one of the most substantial recovery efforts taken since the last review of the species and serves as a model for future removals in Pahranagat Valley (NDOW 2019). Future population monitoring will be important to understanding how Hiko White River springfish respond to the removal of convict cichlids. In 2020, NDOW conducted markrecapture surveys at the north and south springpools of Crystal Springs (NDOW 2020b, Figure 2). At the north springpool, the population was estimated at 1,344 individuals with a 95% confidence interval of 932 to 2,023 individuals. At the South springpool, the population was estimated at 1,948 individuals with a 95% confidence interval of 892 to 5,311 individuals. c. Blue Link Spring – Population estimates for Blue Link Spring have been consistently high in recent years, though a flood event in 2021 resulted in a large portion of the artificial spring being filled in with sediment. Post-flood, 350 springfish were salvaged and translocated to Crystal Springs by NDOW (K. Guadalupe pers. comm.). Subsequently, hand excavation was required to increase open water habitat and depth of the springpool. Few springfish were encountered during hand excavation, which may be due to springfish reducing their activity levels due to low water temperatures. We anticipate that additional work using heavy equipment will be needed in the future to restore function to this system. Currently, we do not have an accurate estimate of the Hiko White River springfish population post-flood (USFWS, 2022).

Minimum Viable Population Size:
No information available.

Resistance to Disease:
No information available.

Adaptability:

Low

Additional Population-level Information:

The Hiko Spring population has decreased substantially since 2000, coinciding with the appearance of red swamp crayfish.

Population Narrative:

The subspecies persists at Crystal and Hiko springs, but in low numbers. The refuge population at Blue Link Spring is currently the largest population.

Threats and Stressors

Stressor: Habitat manipulation
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Hiko and Crystal springs have been modified for agricultural and municipal purposes. The outflow streams are captured in underground pipes and transported to nearby agricultural lands. The remaining surface water is impounded at the spring source. These modifications have resulted in a loss of available habitat for the Hiko White River springfish and its invertebrate food sources.

Stressor: Predation/Competition
Exposure: Nonnative fish and other aquatic species have been implicated in the decline or extirpation of Hiko White River springfish.
Response: Decline in Hiko White River springfish.
Consequence: Populations have been observed to decline following introduction of nonnative species.
Narrative: Predation and competition are responsible for reducing populations of Hiko White River springfish. There are several nonnative species known to occur in the springs and their outflows, including: shortfin mollies, sailfin mollies, mosquitofish, convict cichlids, carp, bullfrog, and red swamp crayfish.

Stressor: Parasitism from exotic/nonnative species
Exposure: Parasites such as tapeworms, nematodes, and anchor worms can occur in native fish populations as a result of nonnative fish introductions.
Response: These parasites do not occur naturally in native fish populations in Pahranagat Valley.
Consequence: Parasites from nonnative species likely result in negative impacts to the Hiko White River springfish, including reduced viability or mortality.
Narrative: Parasites introduced from exotic aquaria fishes may reduce viability or cause mortality to Hiko White River springfish.

Stressor: Recreational use of spring habitat
Exposure: Swimming/bathing is a common activity in the springs.
Response: Increases turbidity and disturbance.
Consequence: May decrease water quality and increase bank erosion.

Narrative: Bathing and swimming in the springs have increased erosion and turbidity, which has decreased water quality and habitat integrity for the Hiko White River springfish.

Recovery

Reclassification Criteria:
No information available.

Recovery Priority Number: 3C

Delisting Criteria:
A self-sustaining Hiko White River springfish population (comprising three or more age-classes, a stable or increasing population size, and documented reproduction and recruitment) is present in the spring pools of Hiko and Crystal springs for three complete generations (or a minimum of 6 consecutive years).

Impacts to the species and its habitat have been reduced or modified to the point where they no longer represent a threat of extinction or irreversible population decline.

No information available.
No information available.

Recovery Actions:
- Maintain and enhance aquatic and riparian habitats in Pahranagat Valley.
- Develop and implement monitoring plans.
- Provide public information and education.
- Establish and maintain populations at Dexter National Fish Hatchery, Key Pittman Wildlife Management Area, and Pahranagat National Wildlife Refuge.
- Enhance aquatic and riparian habitats in the Pahranagat Valley.
- Develop and implement habitat enhancement plans for the Pahranagat Valley.
- Establish and maintain refugia populations.

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS • Continue working with private landowners to foster positive working relationships and develop conservation agreements that facilitate recovery actions to improve the springpool habitat of Crystal and Hiko Springs. Habitat improvement projects may include efforts to eradicate nonnative aquatic species, nonnative vegetation removal/treatment, and changes in agricultural management. • Continue nonnative species control and eradication. Regularly analyze the effectiveness of removal efforts and adapt to new methods as they are identified. • Reevaluate taxonomy as new information becomes available. (USFWS, 2022)

Additional Threshold Information:
- No information available.
- No information available.

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Not applicable.

SPECIES ACCOUNT: *Crenichthys nevadae* (Railroad Valley springfish)

Species Taxonomic and Listing Information

Listing Status: Threatened; March 31, 1986.

Physical Description

Railroad Valley springfish are yellow to olive to gray on the dorsal half of the body, with a dark stripe extending along the dorsal surface from snout to tail; and are silver on the ventral half. The average length of this species is 22.9 to 38.1 millimeters (0.9 to 1.5 inches). They have a chunky body that is two-thirds as wide as deep, with a relatively large head. The dorsal and anal fins are set far back on the body, and the pectoral fins are set low with a vertical base. This fish does not have pelvic fins. Jaw teeth occur in a single row and are bicuspid (USFWS 1996).

Taxonomy

The genus Crenichthys includes Railroad Valley springfish and five subspecies of White River springfish (C. baileyi). Railroad Valley springfish and White River springfish occupy adjacent drainage systems that have no current hydrologic connections. Railroad Valley springfish are distinguished from other springfish by a single row of lateral dark spots along their sides.

Historical Range

Historically found in six spring systems distributed in two areas of Nye County, Nevada: Big Warm Spring, Little Warm Spring, and Duckwater Creek near the Shoshone Indian Reservation; and approximately 43 kilometers (26.7 miles) to the south of the Reservation in Big Spring, Hay Corral Spring, North Spring, and Reynolds Spring on Lockes Ranch (USFWS 2009).

Current Range

Railroad Valley springfish were extirpated from Big Warm Spring by 2003 due to the introduction of red-bellied tilapia (Oreochromis zillii). They were restored to the area in 2007 and currently are found in the springhead to approximately 914 meters (m) (3,000 feet [ft.]) below in the outflow. Railroad Valley springfish persist at Little Warm Spring, but the population's distribution is fragmented due to in-stream barriers. The other four populations at Lockes Ranch continue to persist (USFWS 2009).

Distinct Population Segments Defined

None

Critical Habitat Designated

Yes; 3/31/1986.

Legal Description

On March 31, 1986 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Crenichthys nevadae (Railroad Valley springfish) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two critical habitat units (CHUs) in Nevada (51 FR 10857-10865).

The critical habitat designation for Crenichthys nevadae includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Crenichthys nevadae.

Critical Habitat Designation

The critical habitat designation for Crenichthys nevadae includes two CHUs in Nye County, Nevada (51 FR 10857-10865).

(1) Nevada, Nye County. Duckwater area. Big Warm Springs and its outflow pools, streams, and marshes and a 50 foot riparian zone around the spring, outflow pools, streams, and marshes in T13N, R56E, NE1/4 Sec. 31, SE1/4 Sec. 31, NW1/4 Sec. 32. Little Warm Springs and its outflow pools, streams, and marshes, and a 50-foot riparian zone.

(2) Nevada, Nye County. Lockes Area, North, Hay Corral, Big, and Reynolds Springs and their outflow pools, streams, and marshes, and a 50-foot riparian zone around the springs, outflow pools, streams, and marshes in T8N, R55E, SW1/4 Sec. 11, NW1/4 Sec. 14, SW1/4 Sec. 14, SE1/4 Sec. 15, NE1/4 Sec. 15, SW1/4 Sec. 15.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (51 FR 10857-10865):

(1) warmwater springs and their outflows and surrounding land areas that provide vegetation for cover and habitat for insects and other invertebrates on which the species feeds.

Life History

Feeding Narrative

Adult: Railroad Valley springfish are indiscriminate and opportunistic feeders and ingest a wide variety of foods based on seasonal availability. During the spring, they are primarily herbivores, consuming filamentous algae. In the summer, they eat primarily animal-based foods, with ostracods (e.g., seed shrimp) representing the bulk of their diet. Generally, small fish need to consume a large percentage of their body weight in food every day to meet metabolic demands, which vary directly with the water temperature of the occupied habitat.

Reproduction Narrative

Adult: Little is known about the reproductive life history of the Railroad Valley springfish. Spawning has not been observed in this species, but may be similar to that of the White River springfish. White River springfish deposit one egg at a time, and eggs are fertilized by a male as they are deposited. Eggs fall to the nearest vegetation and adhere tightly. Spawning females deposit 10 to 20 eggs with each spawning. Railroad Valley springfish collected from the spring outflow within 100 m (300 ft.) of the source of Big Spring had poorly developed ovaries throughout the year. Presumably, the water temperature in this reach of the outflow exceeds the tolerance limits for reproduction of this species (USFWS 1996).

Geographic or Habitat Restraints or Barriers

Adult: None

Spatial Arrangements of the Population

Adult: Railroad Valley springfish tend to move seasonally within the spring system to remain within their preferred temperature range.

Environmental Specificity

Adult: Railroad Valley springfish are able to tolerate a wide range of water temperatures, and low dissolved oxygen. They can inhabit a range of habitats within spring pools and outflow channels.

Tolerance Ranges/Thresholds

Adult: High

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: None

Habitat Narrative

Adult: Habitat for the Railroad Valley springfish includes warm spring pools, flowing streams, and adjacent marshes ranging in temperature from 29 to 36°C (84.2 to 96.8°F). This species can occupy a wide range of extreme temperatures with low dissolved oxygen, and tends to move seasonally within the spring system to remain within its preferred temperature range.

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: Seasonal movements

Dispersal

Adult: Local seasonal movement, according to spring temperatures and food availability.

Immigration/Emigration

Adult: None

Dependency on Other Individuals or Species for Dispersal

Adult: None

Dispersal/Migration Narrative

Adult: Railroad Valley springfish move seasonally within their spring habitat, based on water temperatures and food availability. They are adapted to tolerate a wide range of water temperatures, as well as low dissolved oxygen.

Population Information and Trends

Population Trends:

Stable

Species Trends:

Stable

Number of Populations:

6 (USFWS, 2021)

Population Size:

In 1996, the population was estimated to be less than 100 to several thousand individuals (USFWS 1996). Nevada Department of Wildlife has conducted annual monitoring surveys and population estimates for the four populations found on the Lockes Wildlife Management Area from 2005-2020 (NDOW 2020). Population estimates vary annually likely with the availalbility of resources. Surveys conducted in 2020, estimated population sizes at each spring over the recovery criteria threshold of 1,000 fish per site, although none of the populations met this criteria consistently over the entire 15 year monitoring period. The two springs on the Duckwater Shoshone Reservation were most recently sampled in 2018. Although fish were documented at the site via trapping and visual surveys population estimates are not available (NDOW 2020). Available data suggest that there are several thousand fish range-wide (USFWS 2009).

Adaptability:

Moderate

Population Narrative:

Railroad Valley springfish are extant at all six historically occupied thermal springs, which compose their entire designated critical habitat (Figures 1–2). Four of the six springs are located at Lockes Wildlife Management Area (LWMA) and two at Duckwater. Annual population surveys are conducted by NDOW at the four historically occupied thermal springs at LWMA (Big, North, Reynolds, and Hay Corral Spring), and conducts infrequent presence-absence surveys at the two refugia populations (Terrace Hot Spring and Hot Creek Canyon). Only two surveys have been conducted at the occupied springs at Duckwater (Big Warm and Little Warm Spring) since the last 5-year review in 2009. The need for a standardized survey protocol for the Big Warm and Little Warm springs is discussed in the Recommendations for Future Actions described below. (USFWS, 2021)

Threats and Stressors

Stressor: Groundwater withdrawal/water diversion
Exposure: Regional water needs are posing a potential threat to the Railroad Valley springfish habitat’s ecosystem.
Response: Groundwater withdrawal or water diversion would modify or destroy Railroad Valley springfish designated critical habitat.
Consequence: Groundwater development could significantly alter the habitat of this species, and cause negative impacts on populations.
Narrative: Groundwater development is a potential threat, based on an increase in water resource needs for municipalities, lithium brine operations, and oil and gas extraction in

Southern Nevada. The overall impact is unknown and may impact the survival and potentially the recovery of the Railroad Valley springfish (USFWS 2009).

Stressor: Introduction of nonnative fish species
Exposure: Not currently an issue, but the presence of nonnative fish could threaten Railroad Valley springfish populations.
Response: Competition for resources and predation.
Consequence: Severe impacts to populations, including the potential for eradication.
Narrative: Historically, nonnative fish species have been introduced and posed a serious threat to this species. The Railroad Valley springfish habitat has been restored, including eradication of nonnative, predatory fish. Reintroduction of nonnative fish could possibly threaten the continued existence of springfish in their native habitat (USFWS, 2009).

Stressor: Invasive aquatic species removal (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: The Duckwater Shoshone tribe has an annual program to remove non-native shortfin mollies (Poecilia mexicana). The trapping and removal of mollies reduces resource competition and may lead to RVS population increases. Additionally, the reduction in mollies will reduce the need for future RVS translocations from Little Warm Spring to Big Warm Spring (USFWS, 2021)

Recovery

Reclassification Criteria:
None
None
None
None

Delisting Criteria:
1. All six historical spring habitats are permanently protected from adverse modifications through conservation agreements, easements, or fee title acquisitions. (USFWS, 2021)

2. At least 21,000 adult Railroad Valley springfish are present among the six springs, with each population containing at least 1,000 adults and documented annual reproduction and recruitment for 5 consecutive years. (USFWS, 2021)

3. (Optional Criteria) Existing introduced populations should be maintained as refugia. (USFWS, 2021)

Recovery Actions:
- Obtain landowner cooperation.
- Improve and manage Railroad Valley springfish habitats and their populations.
- Monitor Railroad Valley springfish populations and habitats.
- Establish a public information program.
- Acquire private land from willing sellers.

- Secure adequate instream flow on public lands.
- Determine the effects of artesian wells, and of oil and gas exploration and development, on springs in Railroad Valley.
- Determine historic and present habitat characteristics.
- Develop and implement habitat management plans.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: Reassess Recovery Criteria: The RFWO and recovery partners are considering the need to re-evaluate the recovery criteria outlined in the Recovery Plan (Service 1996) based on updated available science. These spring systems are not identical in morphology, therefore the carrying capacity will vary and population benchmarks required for recovery should represent each individual population. Developing benchmarks based on current threats to the species, the three R's (resiliency, redundancy, and representation), and the best available science will accurately represent the recovery potential for RVS. Develop Standardized Monitoring Protocols: Since the last five-year review (2009), there have only been two population surveys on the two springs at Duckwater (Big Warm Spring and Little Warm Spring), both occurring at Little Warm Spring (NDOW 2009–2020). The development and implementation of a standardized monitoring protocol at Big Warm and Little Warm Spring would provide the valuable population data required for meeting current recovery criteria. Continue RVS Translocation and Mollie Removal: The translocation of RVS from Little Warm Spring to Big Warm Spring has been ongoing since 2013. This should continue as an effort to extirpate the population of non-native shortfin mollies that also occupy Big Warm Spring. If these transfers continue, RVS may eventually outcompete and extirpate the mollie population. Additionally, the Duckwater-Shoshone tribe has an annual mollie removal program. The trapping and removal of mollies reduces resource competition and may contribute to RVS population increases. Implement Habitat Improvement Projects: Continue Russian olive management: Control projects to manage Russian olive trees in RVS habitat should continue. Exploring and implementing additional opportunities to manage invasive vegetation at occupied may also improve habitat for RVS. Access road development: The existing access road into LWMA bisects habitat for RVS. Abandoning and reclaiming this access road would decrease disturbance to the open-water habitat area of Big Spring. The Service and NDOW should collaborate to fund and implement this project. Big Spring outflow management: The population in Big Spring at LWMA has benefited from the development of the large, shallow open-water habitat in the lower outflow channel. This is currently the largest Railroad Valley springfish population and may continue to be so in the future. Stabilizing the outflow channel and water delivery efficiency will improve long-term stability of this population. (USFWS, 2021)

Additional Threshold Information:

-
-

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SPECIES ACCOUNT: *Crystallaria cincotta* (Diamond Darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/26/2013; Northeast Region (Region 5) (USFWS, 2015)

Physical Description

The diamond darter is a member of the Perch family (Percidae), a group characterized by the presence of a dorsal fin separated into two parts, one spiny and the other soft (Kuehne and Barbour 1983, page 1). The diamond darter is overall translucent and is a silvery white on the underside of the body and head. It has four wide, olive-brown saddles on the back and upper side (Welsh et al. 2008, p. 1). (USFWS, 2013; USFWS, 2015)

Taxonomy

This species formerly was included in Crystallaria asprella; it was named as a distinct species by Welsh and Wood (2008). (NatureServe, 2015)

Historical Range

This species no longer occurs in most of its historical range (Welsh et al. 2009). The species was last collected in Kentucky in 1929 (Burr and Warren 1986) and in Tennessee in 1939 (Etnier and Starnes 1993). (NatureServe, 2015)

Current Range

An extant population exists in the Elk River of Kanawha River drainage, below Sutton Dam, Kanawha and Clay counties, West Virginia; extirpated populations occurred in the Muskingum River, Ohio; Ohio River, Ohio; Green River, Kentucky; and the Cumberland River drainage, Kentucky and Tennessee (Cincotta and Hoeft 1987, Osier 2005, Welsh et al. 2009, Page and Burr 2011, USFWS 2011). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/22/2013.

Legal Description

On August 22, 2013, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Crystallaria cincotta (Diamond darter) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two critical habitat units (CHUs) in West Virginia and Kentucky (78 FR 52364-52387).

Critical Habitat Designation

The critical habitat designation for Crystallaria cincotta includes two CHUs in Kanawha and Clay Counties, West Virginia, and Edmonson, Hart, and Green Counties, Kentucky (78 FR 52364-52387).

Unit 1: Lower Elk River, Kanawha and Clay Counties, West Virginia.

Unit 2: Green River, Edmonson, Hart, and Green Counties, Kentucky.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Crystallaria cincotta critical habitat consists of five components in West Virginia and Kentucky (78 FR 52364-52387):

(i) A series of connected riffle-pool complexes with moderate velocities in moderate- to large-sized (fourth- to eighth-order), geomorphically stable streams within the Ohio River watershed.

(ii) Stable, undisturbed sand and gravel stream substrates that are relatively free of and not embedded with silts and clays.

(iii) An instream flow regime (magnitude, frequency, duration, and seasonality of discharge over time) that is relatively unimpeded by impoundment or diversions such that there is minimal departure from a natural hydrograph.

(iv) Adequate water quality characterized by seasonally moderated temperatures, high dissolved oxygen levels, and moderate pH, and low levels of pollutants and siltation. Adequate water quality is defined as the quality necessary for normal behavior, growth, and viability of all life stages of the diamond darter.

(v) A prey base of other fish larvae and benthic invertebrates including midge, caddisfly, and mayfly larvae.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species, and which may require special management considerations or protection. The area we are designating as currently occupied critical habitat for the diamond darter is not under special management or protection provided by a legally operative management plan or agreement specific to conservation of the diamond darter, and has not been designated as critical habitat for other species under the Act. This unit will require some level of management to address the current and future threats to the PBFs of the diamond darter. Various activities in or adjacent to the critical habitat unit described in this rule may affect one or more of the PCEs and may require special management considerations or protection. Some of these activities include, but are not limited to, resource extraction (coal mining, timber harvests, and natural gas and oil development activities), construction and maintenance projects, stream bottom disturbance from sewer, gas, and water lines, removal of riparian vegetation, and other sources of nonpoint-source pollution. Management activities that could ameliorate these threats include, but are not limited to: use of best management practices designed to reduce sedimentation, erosion, and streambank destruction; development of alternatives that avoid and minimize streambed disturbances; implementation of regulations that control the amount and quality of point-source discharges; and reduction of other watershed and floodplain disturbances that release sediments or other pollutants. Special management consideration or protection may be required to eliminate, or to reduce to negligible levels, the threats affecting the physical or biological features of each unit. Additional discussion of threats facing individual units is provided in the individual unit descriptions below.

Life History

Feeding Narrative

Adult: The diamond darter feeds on invertebrates and is considered a benthic organism. (NatureServe, 2015)

Reproduction Narrative

Adult: Not available.

Geographic or Habitat Restraints or Barriers

Adult: Restricted to freshwater at depths of <1.5-m; benthic; barriers include dams, high waterfalls, and upland habitat (NatureServe, 2015)

Habitat Narrative

Adult: Habitat includes clean sand, gravel, and cobble runs of small to medium rivers (Page and Burr 2011). This darter has been collected from riffles and pools with <1.5-meter depth, moderate flow, and sand, gravel, and cobble substrates (Osier 2005). Based on habitats used by its sister species (C. asprella), it may also use areas of deeper pool and run habitats (Welsh et al. 2009). Barriers of the diamond darter include dams, high waterfalls, and upland habitat. (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: High (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Unknown (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Data on dispersal and other movements generally are not available. Though larvae of some species may drift with the current. (NatureServe, 2015)

Population Information and Trends

Species Trends:

Declining (USFWS, 2020)

Number of Populations:

1 (USFWS, 2020)

Population Size:

Unknown

Population Narrative:

Total population size is unknown; the species is rare. Despite targeted sampling efforts, only 19 individuals have been collected in the last 30 years since the species was first collected in the Elk River (USFWS 2011). Twelve individuals were collected between 1980 and 2005, and through mid-2011, an additional 7 specimens have been collected (USFWS 2011). The diamond darter's current range continues to be limited to a single population in the lower portions of the Elk River in West Virginia (USFWS, 2020)

Threats and Stressors

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Climate change (as defined by the Intergovernmental Panel on Climate Change (2007, p. 78)) has the potential to increase the vulnerability of the diamond darter to random catastrophic events and to compound the effects of restricted genetic variation and population isolation (USFWS, 2013).

Stressor: Competition from plant and algal species (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The presence of Didymosphenia geminate, an alga known as ''didymo'' or ''rock snot'' has the potential to adversely affect diamond darter populations in the Elk River. Invasive, nonnative plants associated with riparian areas, such as Japanese knotweed, have the potential to adversely affect diamond darter populations in the Elk River. Japanese knotweed is a species native to eastern Asia that was introduced in the United States as an ornamental landscape plant. The species forms dense, monotypic stands that exclude native vegetation. (USFWS, 2013).

Stressor: Geographic isolation and loss of genetic variation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The one existing diamond darter population is small in size and range, and is geographically isolated from other areas that previously supported the species. The diamond darter's distribution is restricted to a short stream reach, and its small population size makes it extremely susceptible to extirpation from a single catastrophic event (such as a toxic chemical spill or storm event that destroys its habitat). Its small population size reduces the potential ability of the population to recover from the cumulative effects of smaller chronic impacts to the population and habitat such as progressive degradation from runoff (non-point-source pollutants) and direct disturbances. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and reducing the fitness of individuals (USFWS, 2013).

Stressor: Habitat destruction and modification (USFWS, 2013)
Exposure:
Response:

Consequence:
Narrative: There are significant threats to the diamond darter from the present and threatened destruction, modification, or curtailment of its habitat. Threats include sedimentation and siltation from a variety of sources, discharges from activities such as coal mining and oil and gas development, pollutants originating from inadequate wastewater treatment, habitat changes and isolation caused by impoundments, and direct habitat disturbance. These threats are ongoing and severe and occur throughout the species' entire current range. There is no information indicating that these threats are likely to be appreciably reduced in the future, and in the case of gas development and associated instream disturbances associated with gas transmission lines, this threat is expected to increase over the next several years as shale gas development continues to intensify (USFWS, 2013).

Stressor: Overutilization (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Overutilization for commercial, recreational, scientific, or educational purposes is a minor threat to the diamond darter. For a species like the diamond darter, with a small range and population size, there is the potential that overutilization for scientific purposes or personal collections could have an effect on the viability of the species. The threat of overutilization is not likely to increase in the future (USFWS, 2013).

Stressor: Small population size and restricted range (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: The small size and restricted range of the remaining diamond darter population make it particularly susceptible to potential extirpation from spills and other catastrophic events (USFWS, 2013).

Recovery

Reclassification Criteria:
Reclassification criteria are not available.

Delisting Criteria:
Delisting criteria are not available.

Recovery Actions:
- Recovery actions are not available.
- Conservation measures are not available.

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS This status review identified the highest priority threats to the diamond darter as well as additional conservation planning, management/threat reduction measures, and survey and monitoring needs for the species. In some cases, additional research is needed to help identify appropriate management actions that would reduce these threats. The following is a list of priority future actions based on the results of this review. Conduct research to

further understand the life history needs of the species, including reproduction and juvenile survival, larval prey preferences, habitat use, and movement, as well as developing techniques to more accurately detect the species and estimate population size and trends. ? Evaluate the species' sensitivity to water quality parameters (such as salinity, conductivity, etc.) to determine conditions needed to support all life stages of the species. ? Evaluate diamond darter genetics to identify any factors that would affect their viability and implement measures to manage for these factors both in the wild and during any captive propagation or restoration efforts. ? Establish protocols to survey and monitor population status and trends within the Elk River and implement monitoring on a regularly established schedule. This should include monitoring water quality and habitat conditions. ? Protect and restore water quality and habitat conditions within the Elk River watershed. ? Coordinate with partners to reduce threats to the diamond darter within the Elk River watershed. ? Control invasive species such as didymo and Japanese knotweed within the Elk River watershed. ? Evaluate streams within the historical range of the species to determine whether conditions are suitable to support the species. ? Implement habitat restoration efforts in streams within the historical range of the species to make them suitable to support the species. ? Develop captive propagation and holding techniques that would allow for the establishment of additional diamond darter populations, or restoration efforts within the Elk River if necessary. ? Establish additional populations within the historical range of the species. (USFWS, 2020)

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SPECIES ACCOUNT: *Cyprinella caerulea* (Blue shiner)

Species Taxonomic and Listing Information

Listing Status: Threatened; Southeast Region (R4) (USFWS, 2015) 4/22/1992

Physical Description

The blue shiner is a medium-sized minnow that grows to about 100 millimeters (4 inches) in total length (Krotzer 1984, Ramsey and Pierson 1986, Mayden 1989, Krotzer 1990). Males are larger than females. Nonbreeding males and females are dusky blue with pale yellow fins. The scales are diamond-shaped and outlined with melanophores. The lateral line is distinct. Breeding males develop nuptial tubercles, a yellowish tint in the fins, and a metallic blue sheen on the body. Females lack tubercles or breeding colors (USFWS, 1995).

Taxonomy

Removed from genus Notropis and placed in genus (formerly subgenus) Cyprinella by Mayden (1989); this change was adopted in the 1991 AFS checklist (Robins et al. 1991). (NatureServe, 2015). The blue shiner (Cyprinella caerulea) was originally described by D.S. Jordan in 1877 as Photogenis caeruleus from tributaries of the Oostanaula River, Floyd County, Georgia. The following year it was placed in the genus Erogala, and in 1891, it was moved to the genus Notropis. Finally in 1981, it was transferred to the genus Cyprinella, following a revision by Mayden (1989). It was designated as a threatened species on April 22, 1992 (U.S. Fish and Wildlife Service 1992) (USFWS, 1995).

Historical Range

Historical range included the Cahaba and Coosa river systems, in the Mobile Bay drainage above the Fall Line, Alabama, Georgia, and Tennessee (NatureServe, 2015)

Current Range

Now restricted to the Conasauga River and tributaries in Tennessee and Georgia, Coosawattee River and tributaries in Georgia, and Weogufka and Choccolocco creeks and lower Little River, tributaries of Coosa River in Alabama (Boschung and Mayden 2004). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Egg: The Blue Shiner is an invertivore that feeds opportunistically on terrestrial insects, supplemented with occasional mayfly and caddisfly immatures. Food is primarily distributed at the surface and mid-water regions of the river (NatureServe, 2015). Individuals appear not to be dependent on others for feeding (inferred from USFWS, 1995). It is possible that the Asiatic Weatherfish, an invasive species, may adversely affect the blue shiner as competition. The blue shiner requires shallow, slow-moving waters that are relatively clear so as to identify their prey visually (inferred from USFWS 2014).

Larvae: Spring and summer stomach samples contained mostly terrestrial insects supplemented with occasional mayfly and caddisfly immatures; probably a surface and mid-water feeder (Etnier and Starnes 1993).; Food Habits: Invertivore (Adult, Immature) (NatureServe, 2015)

Juvenile: Spring and summer stomach samples contained mostly terrestrial insects supplemented with occasional mayfly and caddisfly immatures; probably a surface and mid-water feeder (Etnier and Starnes 1993).; Food Habits: Invertivore (Adult, Immature) (NatureServe, 2015)

Adult: The Blue Shiner is an invertivore that feeds opportunistically on terrestrial insects, supplemented with occasional mayfly and caddisfly immatures. Food is primarily distributed at the surface and mid-water regions of the river (NatureServe, 2015). Individuals appear not to be dependent on others for feeding (inferred from USFWS, 1995). It is possible that the Asiatic Weatherfish, an invasive species, may adversely affect the blue shiner as competition. The blue shiner requires shallow, slow-moving waters that are relatively clear so as to identify their prey visually (inferred from USFWS 2014).

Reproduction Narrative

Egg: Spawns over an extended period in spring and summer; fractional spawner; most spawners are in their third summer, though some mature earlier (see Etnier and Starnes 1993).; (NatureServe, 2015)

Larvae: Spawns over an extended period in spring and summer; fractional spawner; most spawners are in their third summer, though some mature earlier (see Etnier and Starnes 1993).; (NatureServe, 2015)

Juvenile: Spawns over an extended period in spring and summer; fractional spawner; most spawners are in their third summer, though some mature earlier (see Etnier and Starnes 1993).; (NatureServe, 2015)

Adult: This species is oviparous, as females spray their eggs forcefully into crevices in logs or rocks and then abandon them; thus parental investment is low. Eggs are incubated for 7 days. Sex ratio is unknown (USFWS, 2014). Spawning occurs over an extended period in spring and summer--typically their third summer, though some mature earlier. Fitness is inferred to be moderate (NatureServe, 2015). It is likely that multiple clutches of eggs are produced. Typical lifespay is 3 years. Crevices in logs or rocks for egg deposit and warm water--at least for fish in captivity--may be considered key resources needed for reproduction (USFWS, 1995).

Geographic or Habitat Restraints or Barriers

Adult: None (inferred from USFWS, 2014)

Spatial Arrangements of the Population

Adult: Specific habitat patches that may be separated from each other at a distance up to 332 m (USFWS, 2014)

Site Fidelity

Adult: Moderate (inferred from USFWS, 2014)

Habitat Narrative

Egg: Habitat includes cool, clear, small to medium-sized rivers over firm substrates (sand, gravel, or rubble) in pools, backwaters, and areas of moderate current (Lee et al. 1980, Pierson and Krotzer 1987, Etnier and Starnes 1993, Page and Burr 2011).CREEK; MEDIUM RIVER; Moderate gradient; Pool (NatureServe, 2015)

Larvae: Habitat includes cool, clear, small to medium-sized rivers over firm substrates (sand, gravel, or rubble) in pools, backwaters, and areas of moderate current (Lee et al. 1980, Pierson and Krotzer 1987, Etnier and Starnes 1993, Page and Burr 2011).CREEK; MEDIUM RIVER; Moderate gradient; Pool (NatureServe, 2015)

Juvenile: Habitat includes cool, clear, small to medium-sized rivers over firm substrates (sand, gravel, or rubble) in pools, backwaters, and areas of moderate current (Lee et al. 1980, Pierson and Krotzer 1987, Etnier and Starnes 1993, Page and Burr 2011).CREEK; MEDIUM RIVER; Moderate gradient; Pool (NatureServe, 2015)

Adult: The species inhabits small to medium sized rivers of moderate gradient. It requires firm substrates (sand, gravel, or rubble) in pools, backwaters, and areas of moderate current (NatureServe, 2015). The blue shiner occupies specific habitat patches that may be separated from each other at a distance of up to 332 m, despite having no geographic or habitat restraints or barriers. The ecological integrity of the community is inferred to be high based on its dependency on key environmental resources for habitat such as submerged tree roots and continuous water flow. Site fidelity is inferred to be moderate based on the limited area of suitable habitat (USFWS, 2014).

Dispersal/Migration

Motility/Mobility

Egg: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Adult: Moderate (inferred from USFWS, 2014)

Migratory vs Non-migratory vs Seasonal Movements

Egg: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Adult: Nonmigrant (inferred from USFWS, 2014)

Dispersal

Egg: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Adult: Moderate (inferred from USFWS, 2014)

Immigration/Emigration

Adult: None according to the Georgia/Tennessee species populations (inferred from USFWS, 2014)

Dispersal/Migration Narrative

Egg: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Adult: The species is inferred to exhibit moderate motility and dispersal based on its free-ranging but non-migrant behavior. The Georgia/Tennessee species populations have not experienced any migration (inferred from USFWS, 2014). The species is neither locally migrant nor distant migrant (NatureServe, 2015).

Additional Life History Information

Egg: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Larvae: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Juvenile: Nonmigrant: N; Local migrant: N; Distant migrant: N; (NatureServe, 2015)

Adult: Neither local migrant nor distant migrant (NatureServe, 2015)

Population Information and Trends

Population Trends:

Uncertain but possibly in decline (inferred from NatureServe, 2015)

Species Trends:

Uncertain but possibly in decline (inferred from USFWS, 2014)

Population Size:

Unknown (NatureServe, 2015)

Minimum Viable Population Size:

Unknown (USFWS, 2014)

Resistance to Disease:

Unknown--no evidence to suggest that disease threatens the species (USFWS, 2014).

Adaptability:
Low, requiring conservation of numerous local populations throughout its geographical range (USFWS, 2014)

Additional Population-level Information:
The genetic diversity of this species may be declining due to fragmentation and separation of populations by both anthropomorphic and natural causes (USFWS, 2014)

Population Narrative:
This species is now apparently extirpated over much of its former range (Lee et al. 1980). Species is extirpated in the Cahaba River and reduced in numbers in much of its former range (Boschung and Mayden 2004). In the 1990s, the species was apparently declining in range and numbers (Etnier and Starnes 1993), though numbers were seasonally stable at one site that was sampled monthly for one year in the Little River (Dobson 1994). Decline of 50-70% (NatureServe, 2015)

Threats and Stressors

Stressor: Genetic considerations (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The genetic diversity of this species may be declining due to fragmentation and separation of populations by both anthropomorphic and natural causes (George et al. 2008). Disconnected Blue Shiner populations are more susceptible to environmental changes, thereby resulting in an overall decrease of genetic diversity of the species as a whole. Continued loss of connectivity between isolated populations of Blue Shiners will likely limit recovery of the entire species due to attrition of genetic diversity. The long-term viability of the Blue Shiner is based on conservation of numerous local populations throughout its geographic range (Harris 1984). These features are essential for the species to recover and adapt to environmental change. This disjunctive distribution makes Blue Shiner populations vulnerable to extirpation from catastrophic events, such as toxic spills, or changes in flow regime (USFWS, 2014).

Stressor: Habitat destruction and modification (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The range of the Blue Shiner within Alabama, Georgia and Tennessee has been reduced and fragmented by geomorphic and hydrologic changes such as reservoirs, bridges, pipelines and roads; aggregate extraction; major pollution events; an increase in turbidity caused by sedimentation; and general declining water quality attributed to non-sustainable urbanization and land use practices. Studies show that increased urbanization leads to declining water quality in streams and fish assemblages. Water pollution, including eutrophication, low dissolved oxygen, and excessive turbidity, degrades water quality and threatens the species by increasing temperature and reducing the intensity of light entering the water column. Non-point source pollution, in particular, may be correlated with impervious surfaces and storm water runoff.

Pollutants may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and petroleum products. These pollutant sources tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of subsurface and surface waters such that the habitat and food sources for species like the Blue Shiner are negatively impacted. Construction and road maintenance activities associated with urban development typically involve earth-moving activities that increase sediment loads into nearby aquatic systems through storm water runoff during and after precipitation events. Excessive sediment and increased turbidity can degrade Blue Shiner habitat by covering and eliminating available food sources and crevice sites for nesting, disrupt aquatic insect communities, and negatively impact fish growth, physiology, behavior, reproduction, and survivability (USFWS, 2014)..

Stressor: Nonnative species (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The introduced red shiner (Cyprinella lutrensis) may have the capacity to hybridize with the Blue Shiner in the Conasauga River. The red shiner, a mid-west bait bucket species, is considered a conservation threat to native fishes and has spread up river in the Coosa River in nearby Georgia waters. Red shiners aggressively colonize mainstem reaches and can hybridize with the native Blacktail Shiner; they routinely hybridize with the Blue Shiner in the laboratory. The Asiatic Weatherfish (Misgurnus anguillicaudatus) has been reported in the lower Choccolocco Creek and is predicted to be in the midreach of the creek within 10 years. It is unknown if the species will impact the Blue Shiner however it may be possible (USFWS, 2014).

Stressor: Stochastic events (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Blue Shiner meta-populations (spatially separated populations of the same species which interact at some level) remain vulnerable to stochastic and anthropogenic threats. The low density and sporadic presence of Blue Shiners within the Holly Creek drainage in Georgia suggest that populations are likely small and highly localized (USFWS, 2014).

Stressor: Nonnative species and Climate Change (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: The 2014 status review discusses the threat of hybridization with a nonnative species, red shiner (Cyprinella lutrensis). Red shiners readily hybridize with several species of Cyprinella including blue shiners. Red shiners are an aggressive colonizer of habitats where it is introduced and when it is introduced native fishes decline. Climate models simulated an increase in air temperature especially in summer months, extreme precipitation events, and altered discharge (LaFontaine et al.). High and low carbon emission models predicted major red shiner range expansion (Poulos and Chernoff 2014). The hybridization reduces the natural gene pool of species with which it colonizes. Glotzbecker et al. (2016) have found that red shiner hybridization is more of a threat than previously thought. Red shiners already occur in the Conasauga River and Spring Creek in the Little River portion of the species range and are moving downstream and

expected to expand into the last two of the four populations of blue shiners. In addition to hybridization introduced red shiners may be predators of native fish eggs or larvae and a competitor of food resources (Nico et al. 2021, and references therein). (USFWS, 2021)

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
The blue shiner may be delisted when significant threats in specified stream stretches are reduced and populations in those stretches are documented to be viable (USFWS, 1995).

Recovery Actions:

- Determine ecological needs (USFWS, 1995).
- Develop and implement a plan to identify and reduce threats to essential habitats (USFWS, 1995).
- Monitor populations and essential habitats (USFWS, 1995).
- Reintroduce the shiner into former habitats (USFWS, 1995).
- Delineate the species' range by a status survey of historically and currently known locations and other possible stream reaches that have not been sampled (USFWS, 2014).
- Initiate selected long-term monitoring of the species and its habitat at sites within the species range (USFWS, 2014).
- Initiate exploratory survey methods for new populations of the species with environmental DNA survey techniques (USFWS, 2014).
- Establish collection metrics for population variability analysis and minimum and maximum sustainable yield of the populations (USFWS, 2014).
- Revise recovery plan to reflect new information acquired since the recovery plan was written in 1995, and continue implementing pertinent recovery actions from the recovery plan along with determining criteria for population viability (PVA) (USFWS, 2014).
- Initiate a Blue Shiner Recovery Group (USFWS, 2014).
- Work with state, county and town governments in establishing best management and conservation practices to improve water quality and water quantity issues through cooperative agreement, conservation easement, fee title purchase or other means to guarantee safeguards to the Blue Shiner and habitat. Support the States of Alabama, Georgia and Tennessee comprehensive conservation strategy efforts concerning their species of concern (USFWS, 2014).
- Assess threats within current and historical habitats and prioritize plan of action to decrease threats and update recovery action items as required (see no. 2) (USFWS, 2014).
- Determine and maintain instream flows within the habitat of the species (USFWS, 2014).
- Continue partnering with stakeholders (e.g. Forest Service, landowners, non-governmental organizations) in protecting Blue Shiner habitat (USFWS, 2014).
- Restore degraded habitat especially with regard to storm water runoff and other non-point source pollution (USFWS, 2014).
- Develop protection and management plans for all watersheds sites as indicated by information acquired from habitat and population survey studies (USFWS, 2014).

- Restore the Cahaba River population using captive propagation and reintroduction from an appropriate nearby source population (USFWS, 2014).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Delineate the species' range by a status survey of historically and currently known locations and other possible stream reaches that have not been sampled. • Initiate long-term monitoring of the species and its habitat atsites within the species range. • Establish collection metrics for population variability analysis and minimum and maximum sustainable yield of the populations. • Amend recovery plan to reflect new information acquired since 1995, and continue to implement pertinent recovery actions from the recovery plan and determine criteria for population viability analyses. • Initiate a blue shiner Recovery Group. • Work with state, county, and town governments to establish best management and conservation practices in order to improve water quality and water quantity issues that will protect the blue shiner and its habitat. Support the States of Alabama, Georgia and Tennessee comprehensive conservation strategy efforts concerning their species of concern. • Assess threats within current and historical habitats and prioritize plan of action to decrease threats and update recovery action items as required. • Determine and maintain instream flows within the habitat of the species. • Continue partnering with stakeholders (e.g. Forest Service, landowners, nongovernmental organizations) to protect blue shiner habitat. • Restore degraded habitat especially with regard to storm water runoff and other non-point source pollution. • Develop protection and management plans for all watersheds sites as indicated by information acquired from habitat and population survey studies. • Establish a range-wide population genetics study using microsatellites or next generation sequencing to assess genetic diversity of every population. • Create a propagation plan and restore the Cahaba River population using captive propagation and reintroduction from an appropriate nearby source population. (USFWS, 2021)

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SPECIES ACCOUNT: *Cyprinella formosa* (Beautiful shiner)

Species Taxonomic and Listing Information

Listing Status: Threatened; August 31, 1984 (49 FR 33490).

Physical Description

The beautiful shiner is 7.6 centimeters (cm) (3 inches [in.]) in length (NatureServe 2015). Their bodies are compressed, with a depth about same as the length of the head. They have a pointed snout, oblique mouth, and a slightly decurved lateral line with between 26 and 40 scales. The nonbreeding body coloration is tan to olive on the dorsal side and silver on the lateral line, with a lighter-colored belly. Dorsolateral scales are outlined with melanophores. Breeding males are yellow-orange to orange on the caudal, head, and lower fins, with a dark dorsal fin (USFWS 1985).

Taxonomy

Cyprinella formosa was originally described as Moniana formosa by Gilard in 1957. In 1978 this type was corrected to Mimbres and in 1985 it changed again to Notropis santamariae. Cyprinella formosa was then removed from genus Notropis and placed in genus Cyprinella by Mayden in 1989. Some still believe that Cyprinella formosa is a subspecies of N. lutrensis, but it has been found to be distinct. Cyprinella formosa is more closely related to C. bocagrande than to C. lutrensis (NatureServe 2015; USFWS 1985).

Historical Range

The historical distribution of the beautiful shiner ranges from northern Mexico in Sonora and Chihuahua, to southeastern Arizona and southwestern New Mexico. Most of the beautiful shiner's range is in Mexico, with small portions of the population in the United States in the San Bernardino Valley and Mimbred River. In Mexico, the beautiful shiner's range includes the Rio Yaqui system, Guzman basin, and Bavicora and Sauz basins (NatureServe 2015; USFWS 1985; USFWS 2001).

Current Range

Currently, the beautiful shiner occurs in several basins in southeastern Arizona and northwestern Mexico. The beautiful shiner was extirpated in the United States but was reintroduced in Arizona, and reintroduction in New Mexico is planned. Although the beautiful shiner does have a large range in Mexico, the range is thought to be declining due mainly to dewatering and pollution caused by agriculture (NatureServe 2015; USFWS 2001).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/31/1984.

Legal Description

On August 31, 1984 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Notropis formosus (Beautiful shiner) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Arizona (49 FR

34490-34497).
The critical habitat designation for Notropis formosus includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Notropis formosus.

Critical Habitat Designation

The critical habitat designation for Notropis formosus includes one CHU in Cochise County, Arizona (49 FR 34490-34497).

(1) Arizona, Cochise County. All aquatic habitats of San Bernardino NWR in S1/2 Sec. 11: Sec. 14: S1/2 and NE1/4 Sec. 15: T24S. R30E.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (49 FR 34490-34497):

(1) Known constituent elements include small permanent streams with riffles, or intermittent creeks with pools and riffles in the Rio Yaqui drainage with clean unpolluted water. These waters should be free of introduced exotic fishes.

Special Management Considerations or Protections

Section 7(a) of the Act, as amended, requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the Yaqui chub, beautiful shiner and Yaqui catfish, and requires them to ensure that their actions do not result in the destruction or adverse modification of these critical habitats which have been determined by the Secretary. If a “may affect” determination is made, the Federal agency must enter into consultation with the Service. Regulations implementing this interagency cooperation provision are codified at 50 CFR Part 402 and are now under revision (see proposal at 46 FR 29990: June 29, 1983). The only possible activity with Federal involvement that may potentially affect the designated critical habitat is geothermal exploration. This activity is beyond the boundary of the San Bernardino NWR, but could possibly affect underground aquifers supplying surface waters to the critical habitat. Geothermal exploration in the San Bernardino Valley is subject to Federal regulation and licensing by the BLM. It should be emphasized that critical habitat designation may not affect geothermal exploration activities in the vicinity. The designation of critical habitat for these species does not specifically preclude geothermal development in the area. Exploration activities will be allowed to proceed in the vicinity of critical habitat as long as artesian and surface water supplies at San Bernardino NWR are adequately protected. The Act and implementing regulations found at 50 CFR 17.21 and 17.31 set forth a series of general prohibitions and exceptions which apply to all endangered and threatened wildlife. These prohibitions, in part, make it illegal for any person subject to the jurisdiction of the U.S. to take, import or export, ship in interstate commerce in the course of a commercial activity, or sell or offer for sale these species in interstate or foreign commerce. It also would be illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that was illegally taken. Certain exceptions would apply to agents of the Service and State conservation agencies. Regulations codified at 50 CFR 17.22. 17.23, and 17.32 provide for the issuance of permits to carry out otherwise prohibited activities involving endangered and threatened species under certain circumstances. Such permits are available for scientific purposes or to enhance the propagation or survival of the species. In some instances, permits may be issued during a specified period of time to relieve undue economic hardship which would be suffered if such relief were not available. In addition, the two species proposed as threatened, the Yaqui catfish and beautiful shiner, have a special rule which will allow take for educational, scientific, or conservation purposes in accordance with applicable State laws and regulations. Any violation of applicable State law would be a violation of the Endangered Species Act. At present no State laws or regulations are applicable to the Yaqui catfish or beautiful shiner, because neither species is presently found in Arizona. When the reintroduction of these species into Arizona waters occurs, the State will regulate taking in accordance with already existing laws and regulation regarding fishes. This special rule will allow these fishes to be managed as threatened species, thus allowing for more efficient management of the species, and enhancing their conservation.

Life History

Feeding Narrative

Adult: Beautiful shiners are omnivores and are opportunistic feeders that mostly eat insects and small invertebrate, but will also eats detritus, algae, and other plant matter. Their food source is widely distributed throughout their habitat, and they compete for these resources with invasive species (NatureServe 2015; USFWS 1985).

Reproduction Narrative

Adult: Little information is known about the beautiful shiner's reproduction life history and growth characteristics. Beautiful shiners are demersal spawners that spawn during breeding season, from February to June, but the breeding season can extend longer in warm-spring water habitats. Beautiful shiners have a high fitness and low parental care and investment. Eggs are laid in nests that are scooped out by the males in gravel shallows (NatureServe 2015; USFWS 1985).

Geographic or Habitat Restraints or Barriers

Adult: Habitat destruction has limited the range of the beautiful shiner.

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Broad/generalist or community with all key requirements common.

Dependency on Other Individuals or Species for Habitat

Adult: Beautiful shiners do not select cover. However, they do form schools, and schooling may reduce the need for cover (Maes and Maughan 1998). They remain near, but rarely within, beds of plants or other cover along pond margins (USFWS 1985).

Habitat Narrative

Adult: Beautiful shiner (Cyprinella formosa) is a small cyprinid fish native to Rio Yaqui of southeastern Arizona, the Rio Mimbres of southwestern New Mexico, USA, and the Rio Yaqui of northwestern Chihuahua and northeastern Sonora, Mexico (49 FR 34490). Minckley (1973) disputed the New Mexico reference because of lack of specimens. Males are blue-bodied and possess orange fins during the breeding season; females and off-season males are silvery and relatively non-descript. Vives (1993) suggested that egg deposition occurs over small gravel and in crevices. This is likely similar to red shiner (Cyprinella lutrensis) spawning, which show a preference for spawning on red substrates and in two to three millimeter (mm) wide crevices (Gale 1986, Radke 2001) At San Bernardino NWR, captive beautiful shiner have been observed to lay eggs on submerged structures such as gravel substrates and artificial plants, and likely use live vegetation and dead woody structure in refuge wetlands (Radke, pers. com). Beautiful shiner is known to occupy small and medium-sized streams and open lentic habitats (Minckley 1973, Miller et al. 2005). Very little information exists on the autecology and community ecology of the species; in the United States, beautiful shiner population densities appear to naturally be low and captures or observations are rare. (USFWS, 2020)

Dispersal/Migration

Motility/Mobility

Adult: High

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Moderate

Immigration/Emigration

Adult: Unlikely. Has been reintroduced into areas where it was once found.

Dispersal/Migration Narrative

Adult: Beautiful shiners are very mobile fish in their underwater environments; they are nonmigratory and have a moderate dispersal rate. In some areas where the species was previously extirpated, beautiful shiners have been re-established from captive-hatchery populations (NatureServe 2015; USFWS 1985).

Population Information and Trends

Population Trends:

Short-term population level trend ranges from declining less than 30 percent to relatively stable. Long-term trend is decreasing (NatureServe 2015).

Species Trends:

Decreasing

Population Growth Rate:

Decreasing

Number of Populations:

Between 6 and 80 populations across New Mexico, Arizona, and Mexico (NatureServe 2015).

Population Size:

Unknown (NatureServe 2015)

Adaptability:

Moderate

Additional Population-level Information:

The beautiful shiner was extirpated from the United States in 1969, and has since been reintroduced in Arizona; the species still occurs in most of its historical range in Mexico, though it is declining in population size (NatureServe 2015; USFWS 1985).

Population Narrative:

The total adult population size for the beautiful shiner is unknown, but population growth and species level trends are in decline for both the long and short term. The beautiful shiner was extirpated from the United States in 1969, but the species still occurs in most of its historical range in Mexico. The U.S. Fish and Wildlife Service categorized the status of the beautiful shiner as "declining," in both the United States and Mexico. The beautiful shiner was reintroduced in the United States in Arizona in 1990, and these populations appear to be stable (NatureServe 2015; USFWS 1985).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Pollution, lack of water.
Response: Reduction in suitable habitat.
Consequence: Reduction in population numbers.
Narrative: Habitat destruction is the primary reason that the beautiful shiner was extirpated from the United States. Groundwater pumping and diversion of water for agricultural purposes dried up creeks, and additional habitat was degraded by livestock. Diversity of natural landscapes quickly diminished under grazing pressure, especially when ranges were overstocked. Severe grazing pressure (including trampling) also led to incision of stream channels, which drained and desiccated ciénegas. The diversion and modification of stream channels, excessive exploitation of underground aquifers, arroyo cutting, and construction of impoundments all are responsible for the reduction of permanent stream habitat, for failing springs, and for a reduction of the quantity and quality of natural surface waters. In Mexico, the beautiful shiner is in decline because of water development for agriculture, and because of chemical and sewage pollution. Leasing of geothermal resources in the San Bernardino Creek area potentially threatens water supply and quality. Although the area is not a Known Geothermal Resource Area, the Bureau of Land Management has issued leases for geothermal resources on some of their lands adjacent to the San Bernardino NWR. Exploration and development of these leases could potentially cause depletion or pollution of the underground aquifers that supply water to the springs of the refuge, and could thereby result in loss of pollution of the flows of those springs. However, if exploration and development are properly designed and regulated, such effects are not expected (49 FR 33490; NatureServe 2015; USFWS 1985).

Stressor: Introduction of nonnative species.
Exposure: Predation, competition.
Response: More vulnerable to predation, mortality, disease.

Consequence: Reduction in population numbers.
Narrative: The introduction of exotic fish such as the red shiner, blue catfish, and channel catfish has negatively harmed beautiful shiner (Cyprinella formosa) populations. The introduction of nonnative fish has been shown to be detrimental to native fish, and many nonnative fish are permanently establishing themselves in beautiful shiner habitat. In addition, the introduction of exotic fish in Mexico is expected to continue at an increased rate as the interior portions of Sonora and Chihuahua are developed. The introduction of nonnative species has resulted in intense competition for resources, as well as genetic swapping. Breeding between the red shiner and other closely related exotic fish has already led to beautiful shiner hybrids. Beautiful shiner are also predated upon by introduced bullfrogs, largemouth bass, bluegill, black bullhead, channel catfish, and green sunfish (49 FR 33490; NatureServe 2015; USFWS 1985).

Recovery

Reclassification Criteria:
None
None
None
None
None
None
None

Delisting Criteria:
All the following conditions must be met in currently occupied habitat for a period of 10 years before consideration of delisting for beautiful shiner:

Secure and protect San Bernardino Valley aquifers so that all artesian-well and other flows from subsurface sources are perennial. Secure and protect Leslie Creek, Black Draw and Mimbres River, and the New Mexico watersheds to ensure adequate, perennial flow.

Eradicate all nonindigenous fish species and other undesirable organisms, such as bullfrogs, from critical habitat.

Protect critical habitat and other habitats where species of concern occur or are reestablished from human disturbances, including excessive grazing, irrigated agriculture, mining, introductions of nonindigenous species, and water diversion or removal.

Arizona populations of Yaqui beautiful shiner are reestablished, self-sustaining, and secure for at least 10 years in all suitable, existing, and reclaimed San Bernardino/Leslie Canyon NWR habitats.

The beautiful shiner is reestablished, self-sustaining, and secure for at least 10 years in the Mimbres River and other available habitats in its historic range in New Mexico.

Self-sustaining populations are secure in their historic ranges in Mexico.

Recovery Actions:

- Cooperate on recovery with Mexico.
- Manage existing habitats and populations.
- Determine biological requirements of listed species.
- Protect historic habitats of fishes of concern in the United States.
- Assess habitats for reintroduction, and reestablish the species of concern in appropriate habitats in historic ranges.
- Develop information and education programs for all species, their habitats, and the ecosystem(s) on which they depend.
-

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The foremost recommendation for action is that we update our knowledge of beautiful shiner status in the Rio Yaqui and Guzman basin: no new data have been collected since 1994 (Rio Bavispe area; Abarca et al. 1995), and no system-wide surveys have been conducted since those of Hendrickson et al. (1981). In addition to distribution surveys of beautiful shiner in the Rio Yaqui basin, the Guzman beautiful shiner from the Guzman basin need to be sampled. New distributional data are needed to make informed decisions regarding the distributional boundaries of the beautiful shiner complex. The second recommendation for action is that we refine our understanding of the life history characteristics and habitat requirements of beautiful shiner. The species' apparent rarity has made quantitative analysis difficult, but a concerted effort to collect observational and experimental data would greatly benefit our knowledge base. The life history and ecological characteristics of beautiful shiner are important not only in executing recovery actions, but also in refining recovery criteria. When possible, given workloads, a Species Status Assessment should be conducted to guide the development of a recovery plan revision. We recommend a recovery plan be written for both the Yaqui and Guzman beautiful shiner as these are distinct subspecies and not be included in a bundled plan. Lastly, the new recovery plan should provide up-to-date information on populations of this small desert cyprinid. (USFWS, 2020)

Additional Threshold Information:

-
-

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SPECIES ACCOUNT: *Cyprinodon bovinus* (Leon Springs pupfish)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/15/1980; Southwest Region (Region 2) (USFWS, 2016)

Physical Description

Cyprinodon bovinus is a small, robust pupfish up to 50 mm in standard length that has a little wider head and body than most Cyprinodon. The most conspicuous distinguishing features are: (1) lack of the pronounced vertical bars present on the trunk of C. variegatus, a species introduced from coastal waters; (2) lack of the peculiar speckled pattern of c. elegans males (Echelle and Hubbs 1978); and (3) differing from C. pecosensis in having a fully scaled abdomen and, in breeding males, yellow pigment on the dorsal and caudal fins (Echelle and Echelle 1978). (USFWS, 1985)

Taxonomy

The species is most similar to C. tularosa (a species restricted to the isolated Tularosa Basin, New Mexico) which differs in a variety of scale counts and body measurements (Miller and Echelle 1975). Cyprindon bovinus is distinct from the three other Cyprinodon that occupy the Pecos River drainage. An electrophoretic survey confirmed that C. bovinus is genetically distinct from these three species, as well as others (Williams 1981). (USFWS, 1985)

Historical Range

Historical range included the lower portion of Leon Creek and Diamond-Y Spring, Pecos County, Texas. Population at the type locality (Leon Springs) is extirpated (Echelle et al. 1987, Page and Burr 2011). (USFWS, 1985)

Current Range

Currently, the pupfish only occurs in Diamond Y Draw drainage, a flood tributary of the Pecos River in western Texas, located 10 mi (16.1 km) north of Fort Stockton. (USFWS, 2013)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/15/1980.

Legal Description

On August 15, 1980 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Cyprinodon bovinus (Leon Springs pupfish) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Texas (45 FR 54678-54681).

The critical habitat designation for Cyprinodon bovinus includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Cyprinodon bovinus.

Critical Habitat Designation

The critical habitat designation for Cyprinodon bovinus includes one CHU in Pecos County, Texas (45 FR 54678-54681).

(1) Texas, Pecos County. Diamond Y Spring and its outflow stream, Leon Creek; from the head of Diamond Y Spring downstream in Leon Creek to a point 1 mile northeast of the Texas Highway 18 crossing, approximately 10 miles north of Fort Stockton.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (45 FR 54678-54681):

(1) Highly saline habitat preferring quiet waters near the edges of shallow pools with a minimal growth of vegetation.

Special Management Considerations or Protections

The Service believes that the entire known range of the species under consideration should be designated as Critical Habitat. This species occupies an extremely restricted range, and is, therefore, highly susceptible to changes in habitat. The Critical Habitat area designated is an area on which are those evolutionary, ecological, behavioral, and physiological features essential to the conservation of the species. The physical and biological features of this habitat are such as to require special management considerations and protection.

Life History

Feeding Narrative

Juvenile: Eats mainly diatoms and algae, also amphipods, gastropods, and ostracods (Kennedy 1977). (NatureServe, 2015)

Adult: Eats mainly diatoms and algae, also amphipods, gastropods, and ostracods (Kennedy 1977). The extended breeding season, wide salinity and temperature tolerances, and broad food habits of C. bovinus suggest that (e.g., Martin 1972, Echelle et al. 1972), it is a generalist that does best in simple communities with few carpeting species. (USFWS, 1985; NatureServe, 2015)

Reproduction Narrative

Adult: Spawns throughout the year and peaks in July. The pupfish requires hard substrate in shallow water (2-6 in [5-15 cm] deep) for spawning (Leiser and Itzkowitz 2003, p. 101). Egg production and viability, however, may have rather narrow thermal limits (Gerking 1981). Most individuals probably participate in only 1 spawning period (Kennedy 1977). Summer densities may reach 3 or more per sq m (Matthews and Moseley 1990). Males defend territories, driving away other males and potential egg predators (Leiser et al. 2006, pp. 419-420). Spawning events are brief, with the female laying one egg; many spawning events may occur in succession (Leiser et al. 2006, p. 420). The sex ratio of the species is presumed to be 1:1 (Itzkowitz 2011, p. 1). About one quarter of spawning events may be interrupted by a conspecific male, which is attacked by the resident male (Leiser et al. 2006, p. 420). Pupfish reach sexual maturity at 1 in (29 mm) standard length (Kennedy 1977, p. 97). Life span is 20-23 months. (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Isolated (USFWS, 1985)

Environmental Specificity

Adult: Medium (USFWS, 2013)

Tolerance Ranges/Thresholds

Adult: High (USFWS, 2013)

Habitat Narrative

Adult: Habitat consists of shallow saline springs, pools, and outflow streams. This fish is most abundant in quiet water near edges of pools, particularly where there are minimal growths of algae (Lee et al. 1980). Most species of Cyprinodon occur in isolation from other members of the genus (but see Humphries and Miller 1981 for a striking exception). Springs typically are quite hard, with high levels of silica, sulphates, and chlorides (Lee et al. 1980). Waters presently occupied by C. bovinus are relatively saline, with conductivities as high as 18,000 microhms/cm (Echelle and Echelle 1980), i.e., in excess of 15 ppt total dissolved solids. Salinities in the historic habitat at Leon Springs ere 1.4 ppt (Brune 1981). Thus, the species is tolerant of a wide range of salinities and temperatures. Permanent water exists as two semi-isolated reaches in Leon Creek, which originates in seeps and flows 1 km to join another 1-km-long outflow from Diamond-Y Spring; a combined permanent flow then passes another kilometer or so and percolates into the ground; the channel then becomes ill-defined and dry for about 2 km, then water reenters from seeps and springs to form a second 2.7-km reach of perennial flow that ends in two livestock watering tanks; the extent of water in this system varies with climatic conditions; salt encrustations are common along the banks, which are vegetated by sedges and other low marshland plants (Minckley et al. 1991). Spawning occurs in shallow, slow-current areas (Kennedy 1977). Critical maximum temperature ranges from 36.8 C to 41.5 C (Kennedy 1977). Successful development through the hatching stage occurs at 17.5 to 37.75 C in thermally constant laboratory chambers (Williams 1974). The wide thermal ranges for vital functions are typical for pupflshes. Egg production and viability, however, may have rather narrow thermal limits (Gerking 1981). (NatureServe, 2015)

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Not available.

Population Information and Trends

Population Trends:

Long-term trends indicate a relatively stable population (NatureServe, 2015)

Number of Populations:

1 (NatureServe, 2015)

Population Size:

2500 - 10,000 individuals (NatureServe, 2015)

Population Narrative:

Small surviving population was stable in the 1980s (USFWS 1990). Trend over the past 10 years or three generations is uncertain but likely relatively stable. Population in Diamond Y Draw has been estimated at fewer than 10,000 adults (Echelle, pers. comm., in Garrett et al. 2002). This pupfish is common in an extremely small area (Page and Burr 2011). This species is represented by a single occurrence. (NatureServe, 2015)

Threats and Stressors

Stressor: Spring flow loss (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: A major threat to this species is the potential failure of spring flow due to groundwater pumping or drought, which would result in total habitat loss for the species (USFWS 1985, p. 6, USFWS 1980, p. 54678). Diamond Y Spring is the last major spring still flowing in Pecos County, Texas. Pumping of the regional aquifer system for agricultural production of crops has resulted in the drying of most other springs in this region (Brune 1981, p. 356). Historical pumping from the Rustler aquifer in Pecos County may have contributed to declining spring flows, as withdrawals of up to 9 million cubic meters (cm) (7,500 acre-feet (af)) in 1958 were recorded, with estimates from 1970 to 1997 suggesting groundwater use averaged between 430,000 cm (350 af) to 2 million cm (1,550 af) per year (Boghici and Van Broekhoven 2001, p. 218). As a result, declines in water levels in Pecos County wells in the Rustler aquifer from the mid-1960s through the late 1970s of up to 30 m (100 ft) have been recorded (Boghici and Van Broekhoven 2001, p. 213). We assume that groundwater pumping has had some impacts on spring flows of the Diamond Y Spring system in the past; however, they have not yet caused the main springs to cease flowing. Future groundwater withdrawals may further impact spring flow rates if they occur in areas of the Rustler Aquifer that affect the spring source areas. Groundwater pumping withdrawals in Pecos County are expected to continue in the future mainly to support irrigated agriculture (Far West Texas Water Planning Group 2011, pp. 2-16–2-19) and will result in continued lowering of the groundwater levels in the Rustler aquifer. This level of draw down will accommodate 12.9 million cm (10,508 af) of annual withdrawals by pumping (Middle Pecos Groundwater Conservation District 2010b, p. 15). This level of pumping would be 30 times more than the long-term average and could result in an extensive reduction in the available groundwater in the aquifer based on the total thickness of the Rustler strata. Therefore, it is anticipated that this level of groundwater draw down may contribute to continued declines in spring flow rates in the Diamond Y Spring system. (USFWS, 2013)

Stressor: Pollution from oil and gas activities (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The Diamond Y Spring system is within active oil and gas extraction fields (Echelle et al. 2001, p. 26; Karges 2003, p. 144). These activities threaten the Leon Springs pupfish because of the potential groundwater or surface water contamination from pollutants (Veni 1991, p. 83;

Fullington 1991, p. 6). There are still many active wells located within about 328 ft (100 m) of surface waters. In addition, a natural gas refinery is located within 0.5 mi (0.8 km) upstream of Diamond Y Spring. Oil and gas pipelines traverse the habitat, and many oil extraction wells are located near the occupied habitat (Figure 2) (Echelle et al. 2001, p. 26). A catastrophic spill event is possible at any time. Additionally, there are old brine pits from previous drilling within feet of surface waters, which could contaminate the habitat if they were to leak. Oil and gas pipelines traverse under the spring outflow channels and marshes where the species occurs, creating a constant potential for contamination from pollutants from leaks or spills. These activities pose a threat to the habitat by creating the potential for pollutants to enter underground aquifers that contribute to spring flow or by spills and leaks of petroleum products directly into surface waters. Presently, there is no evidence of habitat destruction or modification due to groundwater or surface water contamination from leaks or spills; however, an event catastrophic to the Diamond Y Spring species from a contaminant spill or leak is possible at any time (Veni 1991, p. 83). (USFWS, 2013)

Stressor: Habitat loss from bulrush (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Native bulrush is an imminent threat, as it has encroached upon and thus reduced pupfish spawning habitat (Echelle et al. 2004, p. 132; Itzkowitz 2007, p. 2; Itzkowitz 2010, p. 25). The shallow pools of the Lower Monsanto area are dependent on overflows (for example, water bridges) from the deep pools (Itzkowitz 2010, p. 14). Researchers believe that it is important that these corridors remain open so that the pupfish can travel to the deep pool to escape low temperatures in the winter months and return to the shallow pools in warmer months to breed (Itzkowitz 2010, p. 14). Observations in May 2011 revealed that encroachment of bulrush had completely eliminated the water bridge and filled the shallow pool with vegetation (Itzkowitz 2011, p. 2). Due to the encroachment of bulrush, the elimination of the water bridge, and other detrimental changes to suitable habitat within the Lower Monsanto area, pupfish had disappeared from this locale by 2012 (Itzkowitz 2013a, pers. comm.). Under an awarded section 6 grant, Dr. Itzkowitz and his graduate students began removal of bulrush and restoration of the Monsanto pool area in 2013 (Itzkowitz 2013a, pers. comm.). By May, restoration of the habitat had progressed sufficiently to warrant the reintroduction of pupfish to the Monsanto pool area. On May 15, SNARRC provided 500 juvenile and adult pupfish which were subsequently stocked into the pools (Ulibarri 2013, pers. comm.; Itzkowitz 2013a, pers. comm.). After reintroduction, pupfish breeding behavior was seen almost immediately. As of August 2013, the reintroduction appears to have been successful; however, longer term monitoring is necessary to determine if the population will remain stable over time. (USFWS, 2013)

Stressor: Predation (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The endangered Pecos gambusia occurs sympatrically with the Leon Springs pupfish. The overgrowth of bulrush has altered the dynamics between these two species. Gambusia will feed on the eggs of pupfish (Itzkowitz 2011, p.1). Male pupfish are territorial and actively defend spawning territories and chase away gambusia as they approach to prey upon eggs. When there is an overgrowth of bulrush in pupfish spawning habitat, the cluttered habitat allows large

congregations of gambusia to approach pupfish during spawning events (Gumm et al. 2008, p. 655). If a spawning event is interrupted by gambusia, the eggs may not be laid (Leiser and Itzkowitz 2003, p. 107). Also, the increased number of gambusia at pupfish spawning events may have resulted in changes in the breeding system such that smaller males remain satellites instead of defending available territories. This causes a decrease in the overall number of territorial males, which increases egg predation by Pecos gambusia (Gumm et al. 2008, p. 655, 657). However, Itzkowitz (2010, p. 8, 20) found that creating a more open habitat, by removing bulrush and installing cement tiles, increases the number of territorial pupfish males and disperses the gambusia, thus reducing egg predation. (USFWS, 2013)

Stressor: Hybridization (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Leon Springs pupfish readily interbreed with pupfish of different species. Garrett (1979, pp. 56-57) demonstrated that female Leon Springs pupfish do not discriminate between males of their own species and male sheepshead minnows (Cyprinodon variegatus). Diamond Y Draw is in a remote location owned by The Nature Conservancy. This affords some protection from anthropogenic introductions of non-native fishes; however, the past two introductions of sheephead minnows demonstrate that hybridization events remain a threat of high magnitude for the pupfish (Echelle and Echelle 1997, p. 160; USFWS 1985, p. 6). (USFWS, 2013)

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Future climate change may also impact water quantity for the Leon Springs pupfish. According to the Intergovernmental Panel on Climate Change (IPCC) (2007, p. 1) “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.” Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1,300 years (IPCC 2007, p. 1). It is highly likely that, over the past 50 years, cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007, p. 1). It is likely that heat waves have become more frequent over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007, p. 1). The potential effects of future climate change could reduce overall water availability in this region of western Texas. If this were to occur, spring flows could decline directly because of decreases in recharge from declining precipitation or indirectly as a result of increased pumping of groundwater to accommodate human needs for additional water supplies (Mace and Wade 2008, p. 664). Other effects of climate change include, but are not limited to, alteration of water quality, accelerated invasion of non-native species, and increased disease susceptibility. Because of the extremely small range of the Leon Spring pupfish, any potential changes to this species’ environment could result in the extinction in the wild. For instance, increase in temperatures may affect fecundity, as spawning behavior begins to decline in this species at temperatures of 84°F (29°C) and above (Kennedy 1977, p. 98). (USFWS, 2013)

Stressor: Small population size and stochastic events (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The Leon Springs pupfish is susceptible to threats associated with small population size and impacts from stochastic events. The risk of extinction for any species is known to be highly inversely correlated with population size (O'Grady et al. 2004, pp. 516, 518; Pimm et al. 1988, pp. 774-775). In other words, the smaller the population the greater the overall risk of extinction. Accurate population size estimates have not been generated for this species, but the small area of suitable habitat severely limits the number of individuals. Small population sizes can also act synergistically with other traits (for example, habitat specialization or limited distribution) to greatly increase risk of extinction (Davies et al. 2004, p. 270). Stochastic events from either environmental factors (for example, severe weather) or demographic factors (for example, random birth and death rates) are also heightened threats to species with small population sizes (Melbourne and Hastings 2008, p. 100).

Stressor: Non-native species interactions (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: An exotic snail, Melanoides tuberculata, has become established in Diamond Y Spring (Echelle et al. 2001, p. 14; McDermott 2000, p. 15). The exotic snail is the most abundant large snail in the upper watercourse of the Diamond Y Spring system. Currently, it has not been detected in the lower watercourse (Echelle 2001, p. 26). In many locations, the exotic snail is so numerous that it is, in essence, the substrate in the small stream channel. The effects of this invasive snail on the Leon Springs pupfish are not yet known. It is known that Melanoides can be used as an intermediate host for the parasitic Asian gill fluke Centrocestus formosanus (McDermott 2000, p. 1-2). Centrocestus formosanus has been shown to infect native fish species occurring in other central and west Texas spring systems (McDermott 2000, p. 4; McDermott et al. 2012), and has the potential to negatively impact the Leon Springs pupfish at some point in the future. The gill parasite is highly pathogenic to piscine hosts because their encystment in the gills causes respiratory problems and decreased ability to obtain dissolved oxygen from the water (McDermott 2000, p. 4). However, the gill parasite is not currently known to occur in the Diamond Y Spring system despite the presence of the exotic Melanoides snail (McDermott 2000, p. 19; McDermott et al. 2012). Other introduced non-native species could potentially compete for food or resources (USFWS 1985, p. 7) or transfer pathogens that infect the pupfish. (USFWS, 2013)

Recovery

Reclassification Criteria:
Reclassification criteria are not available.

Delisting Criteria:
Delisting criteria not available.

Recovery Actions:

- 1. Maintain and enhance existing Leon Springs pupfish populations and habitats. (USFWS, 1985)
- 2. Maintain genetic reserves of Leon Springs pupfish. (USFWS, 1985)
- 3. Disseminate information about Leon Springs pupfish. (USFWS, 1985)
- 4. Enforce State and Federal laws protecting Leon Springs pupfish and its habitats. (USFWS, 1985)
- A management program should be implemented immediately to control bulrush in the Leon Springs pupfish habitat. The pupfish population residing in Lower Monsanto Pool has experienced a dramatic loss of spawning habitat from bulrush encroachment (Itzkowitz 2011, p. 2). Removal of bulrush would reestablish the water bridge between the Lower Monsanto Pool and the shallow spawning pools (Itzkowitz 2011, p. 2). Additionally, artificially increasing spawning areas (by installing cement tiles) will prevent bulrush growth (Itzkowitz 2010, p. 5) and may aid pupfish recovery by increasing the number of territorial males and thus decreasing high aggregations of Pecos gambusia at spawning events (Gumm et al. 2008, p. 657). Bulrush encroachment has replaced shallow, open-water habitats with dense vegetation and seems to have contributed both directly and, by altering interspecific interactions, indirectly to a marked decline of Leon Springs Pupfish in Diamond Y Spring (Gumm et al. 2008, p. 656-657). However, any habitat restoration, enhancement, and/or creation efforts in the Diamond Y Spring system benefitting the Leon Springs pupfish should be carefully considered and balanced with the potential negative impacts that may occur to other species in the system, such as the endangered Pecos gambusia and three species of invertebrates that were listed under the Act on August 8, 2013, the Diamond tryonia (Pseudotryonia adamantina), Gonzales tryonia (Tryonia circumstriata), and Pecos amphipod (Gammarus pecos). (USFWS, 2013)
- Currently, there is no regular program in place to monitor population levels and conditions in the Leon Springs pupfish. A program should be employed to regularly monitor population numbers and potential contamination from local oil and gas activities and other threats. (USFWS, 2013)
- A regular program of genetic monitoring of wild populations should be implemented to assess any changes in genetic structure, such as hybridization with non-native fishes (Echelle and Echelle 1997, p. 160; Garrett 2002, p. 442). (USFWS, 2013)
- The hybridization events between the Leon Springs pupfish and the non-native sheepshead minnow demonstrate the importance of maintaining this species at SNARRC. A regular program of genetic monitoring should be implemented, as special care should be taken to maintain the genetic diversity of this captive population (Echelle et al. 2001, p. 27). To maintain genetic variability and rare alleles, the captive populations ideally should be supplemented with genetically pure individuals from natural populations (Edds and Echelle 1989, p. 444); however, the population at SNARRC appears to be the only population of Leon Spring pupfish that has not been introgressed with sheepshead minnow genes (Echelle and Echelle 1997, p. 159-160), so this must be done with the utmost discretion. (USFWS, 2013)
- Echelle et al. (2001, p. 22) recommended stocking the area near the observation tower in Diamond Y Draw with genetically pure fish from SNARRC. The population near the tower showed the highest level of non-native genes (4.2 percent) and appears to have undergone a severe bottleneck, which reduced variability (Echelle et al. 2001, p. 22). To prevent the founder effect, a minimum of 200 adult fish should be introduced in the initial stocking (Edds and Echelle 1989, p. 444). Stockings should consist of small pupfish (<20 mm), added

in early spring to achieve the greatest results (Echelle et al. 2001, p. 27). Unless future information suggests otherwise, current information by Itzkowitz (2010, p. 19) did not recommend stocking the Diamond Y headpool area of the upper watercourse, and Echelle et al. (2001, p. 28) indicated that the lower watercourse area probably should not be stocked with pupfish from SNARRC without justification based on future genetic monitoring. The population in the lower watercourse potentially carries rare alleles that were lost from the SNARRC stock and are, therefore, absent from the upper watercourse as well. (USFWS, 2013)

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Listing of Leon Springs Pupfish as Endangered with Critical Habitat

Final Rule. 45 FR 54678-54681 (August 15, 1980).

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SPECIES ACCOUNT: *Cyprinodon diabolis* (Devils Hole pupfish)

Species Taxonomic and Listing Information

Listing Status: Endangered; March 11, 1967 (32 FR 4001).

Physical Description

The Devils Hole pupfish is a 2.5-cm (centimeter) (1-inch [in.])-long fish and is iridescent blue in color (USFWS 2013).

Taxonomy

The Devils Hole pupfish (Cyprinodon diabolis) was first described by Joseph Wales in 1930. It is distinct from other members of the genus Cyprinodon by its lack of pelvic fins and scales in the periorbital region, and vertical crossbars in males. The Devils Hole pupfish also differs from other members of the Cyprinodon genus by its posterior dorsal fin, long anal fin, and large head and eyes. The Devils Hole pupfish is most closely related to the Ash Meadows Armargosa pupfish (ITIS 2015; USFWS 1990).

Historical Range

Devils Hole pupfish are endemic to Devils Hole—a geothermic pool in a limestone cave in in Ash Meadows, Nevada. The cavern is part of an aquifer that is more than 122 meters (m) (400 feet [ft.]) deep and is linked to groundwater important to Nevada and California. Devils Hole pupfish only live in the top 24.4 m (80 ft.) of the pool, usually remaining on its western edge (NatureServe 2015; USFWS 1990; USFWS 2013).

Current Range

Currently, Devils Hole pupfish are limited to and only live in Devils Hole (Ash Meadows, Death Valley National Park, Nevada), the same place they have historically been found (USFWS 2013).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Devils Hole pupfish are opportunistic omnivores that mostly graze for algae along rocks. They also consume diatoms, spirogyra, and protozoans, but will also eat small invertebrates such as ostracods if they are present in the environment. Devils Hole pupfish mostly remain in the western part of Devils Hole where there is greater algae growth (the species' primary food source) due to higher solar radiation. The growth of the Devils Hole pupfish varies depending on the season, with up to 0.63 cm (0.25 in.) per week in the spring and little to no growth in the winter (NPS 2015; USFWS 1990).

Reproduction Narrative

Adult: Devils Hole pupfish are broadcast spawners that spawn year-round; the height of spawning occurs in April and May. Devils Hole pupfish spawn on shallow rock shelves in Devils Hole pool; after laying the eggs, there is low parental care and investment and young are left to fend for themselves. Devils Hole pupfish live short lives of 1 year. Devils Hole pupfish have moderate fitness and high reproductive capacity (NPS 2015; USFWS 1990; USFWS 2013).

Geographic or Habitat Restraints or Barriers

Adult: Only found in Devils Hole.

Spatial Arrangements of the Population

Adult: Clumped according to resources. Devils Hole pupfish only live in the top 24.4 m (80 ft.) of the pond, usually on its western edge (NatureServe 2015).

Environmental Specificity

Adult: Narrow/specialist (NatureServe 2015).

Tolerance Ranges/Thresholds

Adult: High; Devils Hole pupfish live in extreme environments with water temperature and dissolved oxygen concentrations near the lethal limits for fish (USFWS 2013). The water temperature for Devils Hole averages 33.9 digress Celsius (°C) (93 degrees Fahrenheit [°F]), and dissolved oxygen averages between 1.8 and 3.3 parts per million (ppm) (NatureServe 2015).

Site Fidelity

Adult: High

Habitat Narrative

Adult: Devil Hole pupfish are found in Devils Hole, a geothermal, freshwater pool. Devils Hole pupfish are habitat specialists, and have a very narrow environmental specificity: they occur only in the top 24.4 m (80 ft.) of the pond, usually on its western edge. The Devil Hole pupfish have a high tolerance for extreme environments; the water temperature for Devils Hole averages 33.9 °C (92 °F), and dissolved oxygen levels average between 1.8 and 3.3 ppm. Essential habitat was designated for the protection of the Devil's Hole pupfish. Devils Hole—and 21.760 acres encompassing the area around Devils Hole where groundwater removal most influences the water level in Devils Hole—is essential habitat protected through the National Park Service (NatureServe 2015; USFWS 1990; USFWS 2013).

Dispersal/Migration

Motility/Mobility

Adult: High

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low

Immigration/Emigration

Adult: No

Dispersal/Migration Narrative

Adult: Devils Hole pupfish are limited to Devils Hole, where they are highly mobile but do not migrate; additionally, they have a low dispersal rate and do not immigrate or emigrate (NatureServe 2015; USFWS 1990).

Population Information and Trends

Population Trends:

Decreasing (USFWS 2013). A significant decline of 70 to 90 percent of the population has been observed since surveys for the species were first conducted. Since 2007, an increase in population size (less than 10 percent) has been observed (NatureServe 2015).

Species Trends:

Decreasing

Population Growth Rate:

Long-term significant declines. Short-term slight increase.

Number of Populations:

One

Population Size:

35 Devils Hole pupfish were counted in April 2013, and 65 in September 2013 (USFWS 2013).

Adaptability:

Low

Additional Population-level Information:

The Devils Hole pupfish has a natural high and low population cycle; the population in the spring decreases 35 to 65 percent compared to the fall due to natural die-off (USFWS 2013). Some evidence suggests that the Devils Hole pupfish population numbers fluctuate with the amount of available algae (NatureServe 2015; USFWS 2013).

Population Narrative:

The Devils Hole pupfish is a narrowly endemic species with distribution limited to one population (in Devils Hole). The species is at a great risk of extinction, because they do not have the flexibility to change locations to adapt to changing environments. The Devils Hole pupfish population has significantly declined (from 70 to 905) since population surveys were first conducted. However, since 2007 the population has increased less than 10 percent. During the last counts, 35 Devils Hole pupfish were identified in April 2013, and 65 in September 2013. It is natural for the population in the spring to decrease 35 to 65 percent compared to fall numbers due to natural die off. Because there is such a small population and because of the limited area where Devils Hole pupfish are found, the species has low resiliency, low representation, low redundancy, and low adaptability (NatureServe 2015; USFWS 1990; USFWS 2013).

Threats and Stressors

Stressor: Removal of groundwater
Exposure: Direct; less water for Devils Hole pupfish and their reproduction and feeding.
Response:
Consequence: Decreased population size.
Narrative: Devils Hole pool is a small aquifer, more than 122 m (400 ft.) deep, that is linked to groundwater that is important to Nevada and California. It is thought that the Devils Hole pupfish population first started to decline with the removal of groundwater from wells for irrigation use. This decline was immediately evidenced in a decrease in the Devils Hole fish population. Litigation initiated by the U.S. Department of the Interior to protect Devil's Hole ended with a ruling by the U.S. Supreme Court that upheld a lower court decision mandating the maintenance of a minimum water level. This case ruled that water rights belonged to Devils Hole because it is part of a national monument. This ruling did not halt pumping, but has limited pumping to a level that guarantees sufficient water to inundate the natural rock shelf and sustain the pool. The level being enforced today measures 0.82 m (2.7 ft.) below a datum point situated on the wall in Devil's Hole and adjacent to the water's surface (NPS 2015; USFWS 1990; USFWS 2013).

Stressor: Unknown
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Reasons for the current decline of Devils Hole Pupfish are unknown, and efforts are still being researched. According to the University of Nevada, climate change is affecting the ability of eggs to hatch and of larvae to survive. Other reasons considered for the Devils Hole pupfish decline include reductions in food supply, genetic diversity, and changing environment. Changes to the Devils Hole pool environment can be small, subtle, or complex, which makes it difficult to recognize what is harming the Devils Hole pupfish (NatureServe 2015; University of Nevada 2014; USFWS 1990; USFWS 2013).

Recovery

Reclassification Criteria:
Devils Hole pupfish cannot be delisted but can be down listed to threatened if:

All nonnative animals and plant species must be eradicated from essential habitat. These nonnative species currently include sailfin mollies, mosquitofish, largemouth bass, black bullheads, bullfrogs, crayfish, turban snails, wild horses, salt cedar, and Russian olive.

Secure and protect the Ash Meadows aquifer so that all spring flows return to historic discharge rates, and the water level in Devil's Hole is maintained at a minimum level of 1.4 ft. below the copper washer. Spring discharge rates will be determined by Task number 211 (In recovery plan).

Reestablish water to historic springbrook channels which are free of barriers that eliminate genetic exchange between populations by preventing movement of native fishes throughout their historic range.

The essential habitat must be secure from detrimental human disturbances, including mining, off-road vehicles, and introduction of nonnative species.

All listed fish species are present in all the springs that they have occupied historically, as identified in Appendix A, Table XIII (in recovery plan). For Devil's Hole pupfish, this is Devil's Hole mid-elevation spring.

Amargosa niterwort is present in all localities that it has occupied historically, as identified in Appendix A, Table XV (in recovery plan)

Establish and protect refugee populations of Devils Hole pupfish at Hoover Dam and Amargosa Pupfish Station.

Maintain a population of not less than 300 Devils Hole pupfish individuals during the winter and 700 during late summer.

Delisting Criteria:
At present, it is not possible to determine what measures are needed to indicate that the species is no longer threatened or endangered. As such, the ICT cannot quantify or otherwise define recovery or how to achieve it mechanistically. The immediate need for the Devils Hole pupfish is to continue research at the Ash Meadows Fish Conservation Facility and in the wild at Devils Hole. Understanding the combination of threats, how they interact, or potentially change seasonally, are high priorities for the recovery team. Given the longstanding and extreme peril that characterizes the DHP, most previous studies are indirect or have used surrogate species. The results of these studies have unfortunately been of only moderate utility as the unique cave habitat of high temperatures, low resources and phylogenetic distinctness make the DHP very different from other pupfishes. (USFWS, 2019)

Recovery Actions:
- Secure and protect land and water.
- Manage areas of Management Concern lands and water by returning springs flows to historic level, enhancing and restoring terrestrial and aquatic ecosystems, and minimizing human disturbance in these areas.
- Manage Devils Hole.
- Manage lands under Bureau jurisdiction that are within Ash Meadows essential habitat but outside the area of management concern.
- Manage private lands that are within the essential habitat but outside the area of management concern.
- Investigate biological factors affecting recovery.
- The National Park Service and the Nevada Department of Wildlife launched an emergency plan to reverse the decline of Devils Hole pupfish. An automatic feeder was installed in Devils Hole to provide the Devils Hole pupfish with food, which was thought to be a limiting factor of population growth. This food dispenser has been successful and still remains in place (NatureServe 2015).
- The National Park Service and the Nevada Department of Wildlife launched an emergency plan to reverse the decline of Devils Hole pupfish. In 2006, access into Devils Hole was limited, and it is no longer allowed to remove pupfish for experiments or breeding until the

fall population exceeds 200 fish for at least 3 years (NatureServe 2015).

- Captive breeding populations have been attempted with Devils Hole pupfish; all have failed. A captive hybrid population of Ash Meadows Armargosa pupfish crossed with Devils Hole pupfish, however, has continued to thrive and remains at Shark Reef at Mandalay Bay. Biologists are hopeful that a new Ash Meadows Fish Conservation Facility will more closely mimic the conditions at Devils Hole and will provide a stable environment to establish a refuge population of the species. Protocols have been developed for operation of the facility and the scientific work it will host. This includes protocols (when, how, why, etc.) for moving pupfish, their eggs, and larvae from Devils Hole to the man-made habitat in an attempt to establish a captive population. As of November 2013, some larvae have successfully hatched and are feeding and growing at the facility (USFWS 2013).

Additional Threshold Information:

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SPECIES ACCOUNT: *Cyprinodon elegans* (Comanche Springs pupfish)

Species Taxonomic and Listing Information

Commonly-used Acronym: CSP

Listing Status: Endangered; 03/11/1967; Southwest Region (R2) (USFWS, 2016)

Physical Description

A 2-inch freshwater fish (NatureServe, 2015). The most striking character setting C. elegans apart from all other Cyprinodon species is the peculiar "speckled" color pattern of the male (Stevenson and Buchanan 1973, Echelle and Hubbs 1978). Other distinguishing characteristics of C. elegans are a more streamlined body form than is usual for the genus and the lack of vertical bars (USFWS, 1980).

Taxonomy

It is in the family Cyprinodontidae. Genetically, the Comanche Springs pupfish is markedly divergent from all other species of Cyprinodon in the American Southwest (Echelle and Echelle 1998, p. 855). The species appears most closely related to a complex of three species (C. eximius, C. pachycephalus, and C. macrolepis) in the Rio Conchos basin of northern Mexico and tributaries of the middle Rio Grande in Texas (Echelle and Echelle 1998, p. 855) (USFWS, 2013).

Historical Range

The Comanche Springs pupfish historically occurred in two areas about 90 kilometers apart in the Pecos River drainage, Texas. One inhabited area was Comanche Springs, with its headwaters in Fort Stockton, Pecos County, Texas; this spring dried up in the 1950s and the pupfish population was extirpated (NatureServe, 2015).

Current Range

Comanche Springs pupfish are currently found in three springs and one creek: Phantom Lake Spring (located in easternmost Jeff Davis County, Texas), San Solomon Spring, Giffin Spring, and Toyah Creek near Balmorhea, Reeves County, Texas (Garrett 2003, p. 152) (USFWS, 2013).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: This species is an opportunistic generalist. Adults and immatures are herbivores and invertivores (NatureServe, 2015). Gut analysis of 20 specimens by Winemiller and Anderson (1997, p. 209) revealed Comanche Springs pupfish eat mostly filamentous algae and some snails (Cochliopa texana) (USFWS, 2013).

Reproduction Narrative

Adult: This species breeds during most months of the year (Ono et al. 1983). Most individuals do not live more than 1 year. Spawning occurs in various sites ranging from fast-flowing water (spring outflows) to standing water (USFWS 1981, Ono et al. 1983) (NatureServe, 2015). Comanche Springs pupfish spawning occurs in stenothermal (narrow temperature range) spring outflows and in small, eurythermal (wide temperature range) pools of standing water (Itzkowitz 1969, p. 229). Female sexual maturity is reached at about five months (Cokendolpher 1978, p. 8). Spawning territories are most often over algal mats in swift water (Itzkowitz 1969, p. 229) or large rocks in calm water (Leiser and Itzkowitz 2003, p. 119). In captivity, females can lay 30 eggs per day, which then hatch in five days at 68 ºF (20 ºC; Cokendolpher 1978, p. 8). The males guard eggs until hatching and they aggressively defend their territories against intruders (Itzkowitz 1969, p. 230) (USFWS, 2013).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Critical thermal maximum is about 105 deg F (40.5 deg C)(USFWS, 2013)

Habitat Narrative

Adult: This species inhabits freshwater springs and associated marshes and canals (USFWS 1981). This pupfish usually occurs over mud in current (Page and Burr 2011). Separation barriers include dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). Lab experiments suggest that Comanche Springs pupfish prefer water temperatures between 68-86 ºF (20-30 ºC), and their critical thermal maximum (temperature at which death is likely) is about 105 ºF (40.5 ºC; Gehlbach et al. 1978, pp. 100-101) (USFWS, 2013).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 30-70% (NatureServe, 2015)

Number of Populations:

4 (USFWS, 2013; see current range/distribution)

Population Size:

10,000 - 100,000 (NatureServe, 2015)

Population Narrative:

Drying of Comanche Springs resulted in loss of about half of the historical habitat. This species has experienced a long term decline of 30-70%. During 1999 to 2001, the population in San Solomon Ciénega in Balmorhea State Park averaged 270,000 in summer and approximately 18,000 in winter (Garrett 2003). Population size in the park refugium canal has been estimated to range from 968 to 6480 (see Garrett et al. 2002). Intensive surveys of Phantom Lake Spring from 1993 to 1995 resulted in total abundance estimates of Comanche Springs pupfish as high as nearly 400 individuals during late summer collections (Winemiller and Anderson 1997). As of 2004, the Phantom Spring outflow contained not more than 100-200 C. elegans. Uvalde National Fish Hatchery in Uvalde, Texas, and Dexter National Fish Hatchery and Technology Center in New Mexico maintain captive populations of several thousand individuals. (USFWS, 2013).

Threats and Stressors

Stressor: Habitat loss or modification (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: A primary threat is to the Comanche Springs pupfish is habitat loss from the loss of spring flow due to a decline in groundwater levels. Impacts to spring flows from significant increase in groundwater use or declines in recharge are likely to occur in the upcoming decades. Many springs in the area with similar groundwater sources have failed in the past 50 years, and most of the remaining springs have shown declining trends in outflow. One spring habitat with genetically unique pupfish (Phantom Lake Spring) has gone dry since the 1981 Recovery Plan and is currently being maintained artificially with pumping. The magnitude of impact on Comanche Springs pupfish from the loss of spring flow is extremely high. Because the range of the species is limited to a few small locations, habitat modification due to a decline in spring flows could result in additional local extirpations and eventual extinction. Although there have been recent conservation efforts at Phantom Lake Spring and San Solomon Spring that have improved Comanche Springs pupfish habitat, these efforts would be all for naught if spring flow continued to decline. In addition, the established captive brood stocks at Uvalde and SNARRC are not beneficial if there is no spring habitat in which to re-establish the populations. Secondary threats include habitat modification from water quality degradation and local habitat changes (USFWS, 2013).

Stressor: M. tuberculatus snail and gill parasite (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: An additional factor potentially affecting the Comanche Springs pupfish is the introduced Melanoides tuberculatus snail and its associated gill parasite (Centrocestus formosanus). This exotic trematode from Asia is known to infect the gills of fish in large numbers, causing inflammation and gill tissue destruction (Mitchell et al. 2005, pp. 12-15). Surveys conducted in 1999 found M. tuberculatus at Phantom Lake Spring and San Solomon Spring, but

not East Sandia Spring (McDermott 2000, pp. 14-15). Parasite load was negatively related to survivorship of Comanche Springs pupfish in lab experiments, but there was large variability among individuals in their reactions to the parasite (McDermott 2000, pp. 21, 48). Melanoides tuberculatus also feeds on fish eggs (Phillips et al. 2010, p. 116), but it is unknown if they are impacting Comanche Springs pupfish egg production (USFWS, 2013).

Stressor: Hybridization or competition (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Nearby sources of non-native pupfish that could potentially hybridize with Comanche Springs pupfish include Leon Springs pupfish (C. bovinus) and Pecos River pupfish (C. pecosensis). However, the biggest threat to the Comanche Springs pupfish is the locally abundant sheepshead minnow (C. variegatus). When hybrids of Comanche Springs pupfish and sheepshead minnows reproduce with Comanche Springs pupfish, the fitness of those offspring is low compared to the offspring of hybrids that breed with sheepshead minnows. This finding suggests that Comanche Springs pupfish may be vulnerable to extinction through hybridization. Sheepshead minnow is abundant in East Sandia Spring and Lake Balmorhea (Echelle and Echelle 1994, p. 596) and has the potential to spread into the nearby San Solomon and Phantom Lake Spring (USFWS, 2013).

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: An increased risk of drought in Texas could occur if evaporation exceeds precipitation levels in a particular region due to increased greenhouse gases in the atmosphere (CH2M HILL 2007, p. 18). Expected future warming from climate change could decrease overall availability of water recharging to aquifers in western Texas. Indirectly, any declines in precipitation or increases in evaporation rates from climate change could result in increases in groundwater pumpage. Other indirect climate change effects to water quality, non-native species, disease susceptibility, or other factors are possible (USFWS, 2013).

Stressor: Stochastic events (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The genetically isolated Phantom Lake Spring population of Comanche Springs pupfish may be susceptible to threats associated with small population size and impacts from stochastic events. There were less than 100 estimated Comanche Springs pupfish at Phantom Lake Spring in September 2010 (Lewis et al. unpublished data, p. 5). Stochastic events from either environmental factors (random events such as severe weather) or demographic factors (random causes of births and deaths of individuals) are also heightened threats to the Comanche Springs pupfish because of the small population size (Melbourne and Hastings 2008, p. 100) (USFWS, 2013).

Recovery

Reclassification Criteria:

Not available (USFWS, 2013)

Delisting Criteria:
Not available. The restricted area of natural occurrence of the species and declining flow from the springs probably preclude eventual delisting of the species (USFWS, 2013).

Recovery Actions:
- Maintain and enhance existing CSP populations and habitats (USFWS, 1980).
- Maintain genetic reserve of CSP at Dexter National Fish Hatchery and Balmorhea State Recreation Area (USFWS, 1980).
- Disseminate information about CSP (USFWS, 1980).
- Enforce State and Federal laws protecting CSP and its habitats (USFWS, 1980).
- Monitor populations. The reproductive biology of Comanche Springs pupfish, along with its relatively short life span, combine to cause relatively large fluctuations in population numbers. For this reason, it is important to monitor the populations frequently. Monitoring should be done in several areas representative of the variety of habitats typically occupied by the species. Dates of sampling should be representative of periods of maximum and minimum temperatures and water usage for irrigation. Monitoring should also cover areas that are lacking in recent abundance estimates (for example, Giffin Spring, Toyah Creek, East Sandia Spring) and have had recent habitat restoration (Phantom Lake Spring and the newly created San Solomon Ciénega). Monitoring personnel should obtain appropriate permission from landowners and scientific permits from the Service and TPWD before monitoring begins (USFWS, 2013).
- Monitor habitat. Coincident with monitoring the populations, the monitoring personnel should record such things as rate of water flow and chemistry, abundance and type of aquatic vegetation, changes in shoreline vegetation, and any other indicators of change in habitat quality. Relative abundance of other fish species should also be noted. Monitoring personnel also should be charged with the responsibility of noting and compiling published water flow records (for example, USGS publications on the springs). Special attention should be made to monitor pump system integrity and function at Phantom Lake Spring (USFWS, 2013).
- Enhance existing habitats. The existing habitat should be improved when opportunities arise, only after evaluating the impacts on other endangered species in the area. This includes monitoring current restoration efforts at Phantom Lake Spring and East Sandia Spring, and focusing on improving habitat at Giffin Spring and Toyah Creek. Abundance estimates of Comanche Springs pupfish should be taken before and after restoration projects to evaluate success (USFWS, 2013).
- Control sheepshead minnow throughout the Comanche Springs pupfish range. Monitor canals for the presence of pupfish with characteristics of sheepshead minnows. Where feasible, eliminate sheepshead minnow. Modify canals to serve as fish barriers to help prevent upstream contamination of Comanche Springs pupfish (USFWS, 2013).
- Monitor genetic status of Comanche Springs pupfish populations. Periodically verify genetic purity of existing Comanche Springs pupfish stocks and maintain purity at Balmorhea State Park (canal and San Solomon ciénegas) and Phantom Lake Spring. Population sizes should be maintained at levels sufficient to avoid loss of genetic diversity (USFWS, 2013).
- Monitor for effects of the gill parasite. Comanche Spring pupfish should be routinely inspected for presence of gill parasites in all populations. The host snail and parasites should

be counted to determine trends in parasite load and host snail abundances through time. Any observations of adverse effects of the gill parasites on individual pupfish should be recorded (USFWS, 2013).

- Research sources of Balmorhea area spring flow. Use hydrogeologic techniques to delineate recharge areas for the springs occupied by Comanche Springs pupfish. Determine groundwater flow rates and recharge rates of the aquifers that contribute to surface discharge (USFWS, 2013).
- If necessary, supplement captive breeding stock with additional genetic diversity. Previous research indicates that Comanche Springs pupfish in springhead areas have lower genetic diversity than pupfish in downstream areas (Echelle et al. 1987, p. 680). The current captive breeding stocks of Comanche Springs pupfish originate from the isolated Phantom Lake Spring and may not include the genetic diversity found in downstream populations. Additional research should be conducted to investigate if the wild populations of pupfish at Giffin Spring, East Sandia, San Solomon Spring, and Toyah Creek contain unique alleles not present in the captive stocks. If these wild populations are demonstrated to have greater genetic diversity, this diversity should be preserved in captive breeding stocks in case these populations are lost (USFWS, 2013).
- Update the recovery plan. The recovery plan should be updated to include objective and measurable criteria that take into consideration all of the threats to the species, including climate change. This is currently considered the lowest priority action because other conservation actions described in this 5-year review should be conducted first to accomplish tangible benefits for conservation of the species (USFWS, 2013).

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SPECIES ACCOUNT: *Cyprinodon macularius macularius* (Desert pupfish (includes Rio Sonoyta C. eremus))

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/31/1986; Southwest Region (Region 2) (USFWS, 2016)

Physical Description

The desert pupfish is a small fish, less than three inches long, and a member of the Cyprinodontidae family (Minckley 1973). The body is thickened and laterally compressed; coloration is a silvery background with narrow dark vertical bars on the sides. The mouth is superior and highly protractile, and is equipped with tricuspid jaw teeth. Spine—like projections are characteristic of scale circuli. The dorsal profile is smoothly rounded. Fins are colorless except for a dark ocellus in the dorsal and (rarely) a dark spot on the anal fin. Mature males in breeding condition are brightly colored with the caudal fin and posterior portion of the caudal peduncle yellow or orange, sometimes intense orange—red. Other fins are dark. The body is iridescent light-to-sky blue, especially on the dorsal surface of the head and predorsal region. (USFWS, 2010) The Quitobaquito pupfish (Cyprinodon macularius eremus) differs from other populations of C. macularius primarily as follows (Miller and Fuiman 1987): The males have a longer, wider and deeper head, and broader and deeper body. Distances from the tip of the snout to the pelvic fin insertion, and from snout to anal fin insertion are greater in males. In females, the head is deeper, the (body is slightly deeper, the dorsal fin base is longer, and the depressed anal fin is shorter. The dorsal fin origin is more posterior than for typical C. macularius, and is the same for males and females. Pelvic fins are reduced in size (as they are in other Rio Sonoyta populations) compared to most C. macularius. (USFWS, 1993)

Taxonomy

The desert pupfish complex was historically comprised of two subspecies, the nominal desert pupfish (C. m. macularius), and the Quitobaquito pupfish (C. m. eremus), and an undescribed species, the Monkey Spring pupfish (Cyprinodon sp.) (USFWS 1993). The subspecies are now recognized as three separate species: the desert pupfish (C. macularius), the Sonoyta (Quitobaquito) pupfish (C. eremus) (Echelle et al. 2000), and the undescribed Monkey Springs pupfish which has since been described and renamed the Santa Cruz pupfish (C. arcuatus) (Minckley et al. 2002, Fishbase.org 2010a, b, c; Scharpf 2010). These are part of the western clade of pupfishes (Echelle and Echelle 1993, Echelle 1998). (USFWS, 2010) Miller and Fuiman (1987) further note the distinctiveness of Rio Sonoyta populations compared with Quitobaquito pupfish and considered the former an intermediate link between C. m. macularius and C. m. eremus. (USFWS, 1993)

Historical Range

Historical range included the lower Colorado and Gila river drainages, southern Arizona to southeastern California, and the Salton Sea and Laguna Salada basins, California and Mexico (Minckley and Marsh 2009). (NatureServe, 2015) The currently recognized historical range of C. macularius has changed due to the taxonomic changes of the last 10 years. The recognition and naming of C. eremus and C. arcuatus as separate species removed the Rio Sonoyta and Santa Cruz River basins from the previously known historical range of the desert pupfish. The spatial distribution of the desert pupfish remains relatively stable, though the present historical range represents only a small, peripheral, and fragmented portion of the species' former distribution within the lower Colorado, Rio Sonoyta, and Gila River systems. (USFWS, 2010)

Current Range

Currently this pupfish occurs in California in the Salton Sink (San Felipe Creek/San Sebastian Marsh, upper Salt Creek, and shoreline pools and irrigation drains of Salton Sea, California); El Doctor (3 localities) and Santa Clara Slough (=Cienega de Santa Clara; 2 localities), Sonora, Mexico; Laguna Salada, Baja California, Mexico; and Cerro Prieto (2 localities), Baja California, Mexico (USFWS 2010; see also Hendrickson and Varela 1989, Echelle et al. 2000, Minckley and Marsh 2009). (NatureServe, 2015) The Quitobaquito pupfish (Cyprinodon m. eremus or C. eremus), recently considered to be a separate species, persists in only two populations: one near the United States – Mexico border at Quitobaquito Springs in Organ Pipe Cactus National Monument in Arizona, in the U.S., and the other at Rio Sonoyta in Sonora, Mexico. Additionally, C. m. eremus was stocked into the Quitovac Spring and ponds at Ejido Quitovac in 2007. (USFWS, 2010)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 3/31/1986.

Legal Description

On March 31, 1986 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Cyprinodon macularius (Desert pupfish) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes four critical habitat unit (CHUs) in Arizona and California (51 FR 10842-10851).

The critical habitat designation for Cyprinodon macularius includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Cyprinodon macularius.

Critical Habitat Designation

The critical habitat designation for Cyprinodon macularius includes four CHUs in Pima County, Arizona and Imperial County, California (51 FR 10842-10851).

(1) Arizona: Pima County: Quitobaquito Springs WNW Lukeville, Arizona in Organ Pipe Cactus National Monument, in T17S R8N; and a 100 foot riparian buffer zone around the spring.

(2) California: Imperial County: San Felipe Creek, Approximately 8 1/2stream miles and 100 feet on either side of San Felipe Creek or the stream channel commencing at the State Highway 86 bridge crossing (approximately 1/4 mile south of the intersection of Hwy. 78 and Hwy. 86) upstream to the eastern boundary of Section 31, T12S: R11E: including those areas of the stream channel in: T12S R11E Section 17, 18, and 19; T12S: R10E Section 22, 23, 24, 26, 27. 28, 29, and 32.

(3) California: Imperial County: Carrizo Wash. Approximately 1 3/4 stream miles and 100 feet on either side of or the stream channel commencing at the confluence of Carrizo Wash with San Felipe Creek upstream to the southern boundary of N1/2 Section 33: T12S R10E; including those areas of the stream channel in T12S; R10E Section 27, 28, and N1/2 Section 33.

(4) California: Imperial County: Fish Creek Wash. Approximately three-fourths of one stream mile and 100 feet on either side of the stream channel from the confluence of Fish Creek Wash with San Felipe Creek upstream to the southern boundary of N1/2 Section 32 T12S; R10E; including those areas of the stream channel in T12S R10E: Section 29 and N1/2 Section 3.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (51 FR 10842-10851):

(1) Constituent elements for all four areas designated as critical habitat include clean unpolluted water that is relatively free of exotic organisms, especially exotic fishes, in small slow-moving desert streams and spring pools with marshy backwater areas.

Special Management Considerations or Protections

BLM’s current management of the portion of critical habitat within the San Sebastian Marsh/ San Felipe Creek ACEC and interagency land exchange efforts in progress since 1960 are also apparently compatible with the critical habitat designation. in addition, there is no known involvement of Federal funds or permits for the private land included in the critical habitat designation. For these reasons, no adjustments to the boundaries of the proposed critical habitat were warranted.

Life History

Feeding Narrative

Adult: Larval pupfish in the laboratory begin feeding on tiny invertebrates within a few hours to a day after hatching (Crear and Haydock 1971) and presumably do so in the wild as well. As they grow, wild fish become opportunistic omnivores, consuming whatever variety of algae, plants, suitably-sized invertebrates, and detritus is available (Cox 1966 and 1972, Naiman 1979). Adult foods include ostracods, copepods, and other crustaceans and insects, pile worms, molluscs, and bits of aquatic macrophytes torn from available tissues. Detritus or algae are often predominant in their diets. Pupfish at Quitobaquito Spring have been reported to eat their own eggs and young (Cox 1972), and it has been suggested (Loiselle 1980) that males differentially consume eggs within their territories that were fertilized by other males. Pit digging, the active excavation of soft bottoms in search of foods, is a pupfish behavior described in detail by Minckley and Arnold (1969); these pits are defended when occupied. Foraging is typically a daytime activity, and fish may move in response to daily warming from shallower water during morning to feed in deeper places later in the day. May burrow into loose substrate and become dormant in winter when temperatures are extreme. Growth rate is dependent upon age, habitat and environmental conditions, and population density. Desert pupfish from the Salton Sea hatch at 0.4-0.5 cm total length and may double in length within the first 8 weeks of life. Depending primarily upon temperature, size ranges from 1.5 to 2.8 cm at 24 weeks of age, and lengths of 4.5 to 5.0 cm are attained in the laboratory by the end of the first growing season

(Kinne 1960). Maximum length (to 7.5 cm (Moyle 1976)] may be attained by the second summer. (USFWS, 1993; NatureServe, 2015)

Reproduction Narrative

Adult: Spawning: spring and summer, or year-round in warm constant temperature environments. Each female may lay 50-800 eggs or more/season, depending on her size (Moyle 1976). Males defend eggs. Eggs hatch in 10 days at 20 C (within about 3 days according to Matthews and Moseley 1990). Reproduces at age 2-3 months in constant warm temperatures; first breeds at about 1 year in variable temperatures. Up to 2-3 generations per year (Matthews and Moseley 1990). Typically swims in loose schools, often in groups of similar size and age (Moyle 1976). Life span in the wild appears highly variable; from less than a year for some populations (Minckley 1973), two years for others (Moyle 1976). (USFWS, 1993; NatureServe, 2015)

Environmental Specificity

Adult: Low (USFWS, 1993)

Tolerance Ranges/Thresholds

Adult: High (NatureServe, 2015)

Habitat Narrative

Adult: Desert pupfish occupied a diversity of habitats ranging from cienagas and springs to small streams and margins of larger bodies of waters. Most habitats were shallow and had soft substrates and clear water. Abundance of aquatic vegetation and invertebrates probably varied seasonally, with lowest levels associated with harshest conditions. Pupfish have an extraordinary ability to survive under conditions of high water temperature (to 450C, Lowe et al. 1967), low dissolved oxygen concentration (0.1-0.4 milligrams per liter (mg/L), (Barlow 1958b)], and high salinity [salt concentrations twice (68 grams per liter) that of seawater, Lowe et al. 1967], which exceed tolerances of virtually all other freshwater fishes (see also Kinne 1960, Kinne and Kinne 1962 a,b). They also survive abrupt, absolute changes in both salinity (10-15 grams per liter (gm/L)] and temperature (22—260C) (Kinne 1960, Lowe and Heath 1969) that are lethal to most fishes. In less harsh environments where a greater diversity of fishes was found (e.g., margins of larger streams and rivers), pupfish typically occupied water shallower than that inhabited by adults of most other species. (USFWS, 1993)

Dispersal/Migration

Motility/Mobility

Adult: High (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Typically swims in loose schools, often in groups of similar size and age (Moyle 1976). The desert pupfish is nonmigratory. However, dispersal may occur occasionally during high waters due to flooding. (NatureServe 2015; USFWS 1993)

Population Information and Trends

Population Trends:

Stable (USFWS, 2019)

Number of Populations:

11 wild (California = 5, Arizona = 1, and Mexico = 5) and approx 25 introduced((USFWS, 2019)

Population Size:

>1,000,000 individuals (NatureServe, 2015)

Population Narrative:

The populations of Desert Pupfish are described using three tiers, related to the viability and genetic value of each one. Collectively, there are 11 extant natural populations of Desert Pupfish known in the wild in the United States and Mexico (California = 5, Arizona = 1, and Mexico = 5; Tier 1 populations in the Recovery Plan). Many reestablishments have been attempted. Approximately 25 transplanted populations of Desert Pupfish exist in the wild at present, although this number fluctuates due to the ongoing establishment (and failure) of populations (Tier 2 and 3 populations in the Recovery Plan) (Service 1993, Moyle 2002, Voeltz and Bettaso 2003, Robinson and Mosher 2018, Service files). Approximately 47 captive or refuge Desert Pupfish populations (that do not qualify as Tier 3) exist, comprised of 34 in Arizona, 8 in California, and 5 in Sonora, Mexico. Range-wide status of Desert Pupfish is poor but stable, although the number of populations has been increasing in Arizona due to an active recovery program (Duncan and Clarkson 2013; Robinson and Crowder 2015; Robinson and Mosher 2018). The status in California, on the other hand, is more mixed, with some losses and some gains across the three tiers. (USFWS, 2019)

Threats and Stressors

Stressor: Water loss (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Groundwater extraction was considered a threat in the listing (51 FR 10842) and in the recovery plan (USFWS 1993). It is still considered a threat; especially at Quitobaquito, Rio Sonoyta (Brown 1991), and El Doctor (P. Reinthal, University of Arizona, pers. comm.). Water extraction removes and degrades habitat, leaving higher concentrations of salts, toxic contaminants, and sediment in the remaining volumes of water and lower amounts of dissolved oxygen, and thus interacts with other compounding threats. Water reductions could lead to less shallow-water habitat preferred by the desert pupfish. Slight increases in salinity could benefit desert pupfish, by reducing populations of problematic nonnative fishes. However, if salinity keeps increasing, wetland areas may become unsuitable even for pupfish. Any change to the water budget at Cienega de Santa Clara could be detrimental to the desert pupfish there. Groundwater withdrawal in the Rio Sonoyta drainage has exceeded recharge for decades. In addition, the pumping capacity is about twice of what is withdrawn in an average year (Brown 1991, Pearson and Conner 2000). (USFWS, 2010)

Stressor: Watershed health (USFWS, 2010)

Exposure:
Response:
Consequence:
Narrative: Watershed condition has been and continues to be a concern over most of the Southwest. Recreational pursuits that have the potential to increase soil erosion (i.e. off-highway vehicles (OHVs)) are a concern for desert pupfish because of their impacts to watershed health, rather than any direct effects. Overgrazing and historically extensive logging combined with climatic events (drought followed by rain events), have led to increased erosion and deeper channelization (Miller 1961, Bahre 1991), which do not provide the shallower, clear, and vegetatively complex wetlands preferred by the desert pupfish (Hanes 1996). Extensive logging is no longer a threat to desert pupfish or their habitats. Improper grazing at a watershed level probably does not impact desert pupfish populations anymore, except at the Rio Sonoyta. Grazing of occupied sites still occurs in Mexico and the United States. However, grazing in the United States is better managed and much less of a concern for its impacts to desert pupfish habitat. Urbanization and other human activities can and continue to impact watershed health and functioning. (USFWS, 2010)

Stressor: Contaminants (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Environmental contaminants, such as heavy metals, accumulating in water sources were given as threats at the time of listing, particularly in the form of mercury. At this time, selenium seems to be the element of most concern for fishes in the Salton Sea (Saiki 1990, California Regional Water Quality Control Board 1991, McClurg 1994, Saiki et al. 2008). In addition to conditions of elevated salinity, contaminants are still present in irrigation drains entering the Salton Sea. These include problematic levels of heavy metals and organochlorines entering the Salton Sea, and effects to dissolved oxygen in the Salton Sea (Saiki 1990, Matsui et al. 1992). Salinity in the Salton Sea is expected to continue increasing (Saiki 1990, Matsui et al. 1992) to the point the Sea will be inhospitable for all fish (California Regional Water Quality Control Board 1991, McClurg 1994), unless planned restoration actions occur. The only new threat identified is that endocrine disruptors have been noted in the Salton Sea irrigation drains (C. Roberts, USFWS, pers. comm., 4 August 2010). (USFWS, 2010)

Stressor: Grazing (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Livestock grazing was not mentioned as a threat in the final rule (51 FR 10842), though habitat modifications from grazing was mentioned in the recovery plan (USFWS 1993). The small size and high physical tolerance of the desert pupfish allow it to exist in small amounts of water spanning a wide variety of extreme habitat and water quality conditions (USFWS 1993). Due to the scarcity of water in the desert pupfish's desert habitat and the tendency for cattle to congregate in watered areas, cattle are attracted to desert pupfish habitats that can lead to local impacts quickly. Low water conditions combined with congregations of cattle activity (grazing, watering, hoof action) can lead to additional reductions in water, physiological effects of reduced water quality, bank trampling, fragmentation of contiguous water, isolation/stranding and trampling of fish and eggs (Roberts and White 1992), and loss of habitat through de-watering.

Long-term or seasonal drought can also exacerbate these conditions. Round-up of trespass cattle within these small enclosed areas could cause cattle congregations to increase their hoof action and cause movement into fish habitat. Cattle can cause disturbance, a decline in water quality, and mortality of fish and desert pupfish eggs, particularly at the perimeter of ponds, springs, wells, and shallow wetland areas, by reducing the distribution and abundance of water and isolating fish and eggs into inhospitable areas (Kauffman and Krueger 1984, Fleischner 1994, and Belsky et al. 1999). Carefully controlled grazing around some of the small pond habitats as a tool to manage problematic aquatic vegetation could actually be beneficial to the desert pupfish (Kodric-Brown and Brown 2008). Although impacts from livestock grazing have been problematic in some areas, as a result of consultations many of the impacts have been alleviated through fencing and grazing rotations. (USFWS, 2010)

Stressor: Disease (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Desert pupfish are susceptible to parasites and predation and competition from nonnative fish and other species. Desert pupfish are known to suffer infestations of anchor worm (Lernea spp.) (51 FR 10842) (Robinson 2009). Miller and Fuiman (1987) noted a nematode parasite present in desert pupfish collected from Quitobaquito Springs in Organ Pipe Cactus National Monument and hypothesized, after Cox (1966) that the parasites resembled a nematode known from birds and that waterfowl or shorebirds were a possible vector for introduction to the desert pupfish. It is therefore conceivable that many desert pupfish populations are at risk of infestation by this parasite. However, the specific effects to individual desert pupfish or populations are unknown. Lernea can kill its host, though largely through secondary infections. (USFWS, 2010)

Stressor: Predation/ non-native fish (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Predation and competition from nonnative fish have been identified as main causes of the decline of the species (51 FR 10842, USFWS 1993). Nonnative fish are still a major threat to the desert pupfish at this time. Martin and Saiki (2009) found the remains of C. m. macularius in the gastrointestinal contents of one longjaw mudsucker. In addition, they found unidentifiable fish remains in the gastrointestinal contents of sailfin molly, porthole livebearer, longjaw mudsucker, redbelly tilapia, Mozambique tilapia, and western mosquitofish. In an earlier study (2005) they found the abundance of C. m. macularius to be inversely related to the abundance of nonnative fish. It has long been assumed that western mosquitofish have a negative impact on desert pupfish (Deacon and Minckley 1974, USFWS 1993), through similar mechanisms by which they affect other small fishes, such as competition for food and the predacious habits of mosquito fish upon young fish, as well as fin damage under crowded conditions (Meffe at al. 1983, Meffe 1985). Martin and Saiki (2009) found unidentifiable fish remains in western mosquitofish. They also believed there was significant dietary overlap between desert pupfish and western mosquitofish. To the contrary however, Martin and Saiki (2005) also found the abundance of desert pupfish was positively correlated with the presence of western mosquitofish. We surmise that this result stems from the high tolerance of both species to poor water quality and from competition with the many other nonnative fish individuals present in

shared habitats. Because nonnative aquatic species are present in many occupied or potential desert pupfish habitats and nonnative aquatic species are exceedingly difficult to get rid of once established, nonnative aquatic species continue to be a major threat to the conservation of the desert pupfish. (USFWS, 2010)

Stressor: Bullfrog (USFWS, 1993)
Exposure:
Response:
Consequence:
Narrative: Non-native bullfrog (Rana catesbeiana) may also prove problematic in the management of desert pupfish. This species was introduced to California early in the 1900s (Storrer 1922) and rapidly became established over a wide geographic range in the West, where it has extirpated or displaced several native amphibians (Clarkson and deVos 1986). The bullfrog is an opportunistic omnivore with a diet throughout its range that includes fish (Frost 1935, Cohen and Howard 1958, Brooks 1964, McCoy 1967, Clarkson and deVos 1986). Its potential for impact on desert pupfish was demonstrated in an artificial pond at Arizona State University, where a population of desert pupfish numbering in the thousands was nearly eliminated by fewer than 20 adult bullfrogs over a period of approximately a year. Natural and re—established populations of desert pupfish may thus be at risk where bullfrogs become established, and their removal may be required to assure viability of the native fish. (USFWS, 1993)

Stressor: Genetic diversity (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Many occupied pupfish localities are small, fragmented, and highly threatened. The theory of island biogeography can be applied to these isolated habitat remnants, as they function similarly (Meffe 1983, Laurenson and Hocutt 1985). Species on islands are more prone to extinctions than continental areas that are similar in size (MacArthur and Wilson 1967) because smaller areas tend to have fewer resources and fewer opportunities for exchange of genetic material from other desert pupfish populations than larger areas of habitat. As the genetic pool becomes more separated and limited, a population trapped in a small pond has decreasing chances of developing genetic diversity and potential adaption to changes, and of sustaining environmental stochasticity in the long run. Based on the isolated nature of desert pupfish populations, when only a few populations of a rare fish species occur, the extirpation of one of those populations can be almost as critical as that of a recognized species extinction (Meffe 1983). (USFWS, 2010)

Stressor: Climate change (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: That much of the American southwest has experienced serious drought recently is well known. What is known with far less certainty is how long droughts may last. State-of-the-art climate science does not yet support multi-year or decade-scale drought predictions. However, instrumental and paleoclimate records from the Southwest indicate that the region has a history of multi-year and multi-decade drought (Hereford et al. 2002, Sheppard et al. 2002, Jacobs et al. 2005). Multi-decade drought in the Southwest is controlled primarily by persistent

Pacific Ocean-atmosphere interactions, which have a strong effect on winter precipitation (Brown and Comrie 2004, Schneider and Cornuelle 2005). Also, persistent Atlantic Ocean circulation is theorized to have a role in multi-decadal drought in the Southwest, particularly with respect to summer precipitation (Gray et al. 2003, McCabe et al. 2004). Given these multi-decade “regimes” of ocean circulation, and the severity and persistence of the present multi-year drought, there is a fair likelihood that the current drought will persist for many more years (Stine 1994, Seager et al. 2007), albeit with periods of high year-to-year precipitation variability characteristic of Southwest climate. Many of the predictions about the impacts of climate change are based on modeling, but many predictions have already occurred. The tree die-offs and fires that have occurred in the south-west early in this century show the impacts of the current drought. Because of drought, climate change, and human population growth, negative effects to aquatic habitat in the range of the desert pupfish continue to occur. The basin’s rivers, streams, and springs continue to be degraded, or lost entirely. Therefore, while it appears reasonable to assume that desert pupfish may be affected by climate change, the Service lacks sufficient certainty to know how climate change specifically will affect desert pupfish beyond loss, reduction, and degradation of habitat. (USFWS, 2010)

Recovery

Reclassification Criteria:
(1) Naturally occurring populations in the United States and Mexico are established and secure. These include seven Management Units at 14 known locations: (a) San Felipe Creek/San Sebastian Marsh, California; (b) The rest of the Salton Sink, California. This includes two populations, managed separately, Salt Creek, and shoreline pools and irrigation drains of Salton Sea; (c) El Doctor (3 localities) and Santa Clara Slough (2 localities), Sonora; (d) Laguna Salada, Baja California; and (e) Cerro Prieto (2 localities), Baja California, Mexico; (f) Rio Sonoyta, Sonora; (g) Quitobaquito Spring, Arizona; (USFWS, 2019)

(2) Populations of Desert Pupfish are reestablished and secure within probable historical range according to specifications detailed in task 2 of this plan and Table A below (which include the persistence of a reestablished, secure population for a minimum of 10 years); (USFWS, 2019)

(3) A protocol for exchange of genetic material among reestablished populations is developed and implemented to ensure maintenance of natural levels of allelic genetic diversity; and (USFWS, 2019)

(4) Population and genetic monitoring plans as outlined below in the stepdown of this plan are devised and implemented to routinely assess the status of all populations. “Secure” populations are defined as formal protection of habitat and water rights by methods such as land and water rights acquisition, legislation, or management agreement, and maintenance of a genetically pure, self-sustaining, stable or increasing (viable) population. Until additional information becomes available, a viable population (Lacy 1987, Ryman and Utter 1987, Soule 1987, Templeton 1990) will include not fewer than 500 overwintering adults or existing numbers, whichever is greater, in a normal sex ratio with in-situ reproduction and recruitment sufficient to maintain that number. (USFWS, 2019)

Delisting Criteria:

(1) Populations of the seven Desert Pupfish Management Units (Table B, below; Echelle et al. 2007:13) are reestablished and secure within historical range of the species according to specifications detailed in task 2 of the Recovery Plan and, at least two of these populations are in a large riverine system, such as in the Colorado, Gila, Hardy, Santa Cruz, San Pedro, or Salt Rivers (USFWS, 2019);

(2) A population that meets all other requirements (Service 1993:19) to qualify as a Tier 2 population must persist for a minimum of 20 years (as opposed to 10 years as described in conditions defining a Tier 2 population for downlisting). (USFWS, 2019);

(3) The specified total number of populations (Table B) must be achieved and continuously maintained for 20 years. (USFWS, 2019)

Recovery Actions:

- Protect natural populations and their habitats. (USFWS, 1993)
- Re-establish populations. (USFWS, 1993)
- Establish a refugium population of Quitobaquito pupfish. (USFWS, 1993)
- Develop protocol for exchange of genetic material. (USFWS, 1993)
- Monitor natural and replicated populations. (USFWS, 1993)
- Determine factors affecting population persistence. (USFWS, 1993)
- Information and education. (USFWS, 1993)
- The Desert Pupfish Recovery Plan should be revised to incorporate taxonomic changes of the desert pupfish and updated genetic and management protocols. A specific genetic protocol should be developed, using work by Echelle et al (2007) as a template for management of C. m. macularius and C. m. eremus refuge populations. Their recommendations include establishing at least four large primary refuge populations, with each one representing one of the four groups of wild C. m. macularius and C. m. eremus. The primary refuge populations would receive periodic supplementation with wild fish. They also recommend that 10 or more secondary refuges representing each of the four wild source regions be established. Their report contains additional recommendations on management of the refuge populations (Echelle et al. 2007) that would be of great use in developing an updated, standardized protocol. A recovery plan amendment or revision is also indicated based on recommendations by Loftis et al (2009) that delineate a different set of management units in the Salton Sea than is recognized in the existing recovery plan, and to reflect the changed taxonomy. (USFWS, 2010)
- A technical correction should be published in the Federal Register to update the List of Endangered and Threatened Wildlife to include three taxa, the Quitobaquito Springs pupfish (C. eremus), the desert pupfish, (C. macularius), and the Santa Cruz pupfish (C. arcuatus). (USFWS, 2010)
- Develop at least four Refuge Ponds in San Luis, Sonora (and vicinity) for desert pupfish from Cienega de Santa Clara. (USFWS, 2010)
- Emphasize conservation at wild sites, where progress can be made, and use Safe Harbor Agreements only where no other progress can be made. (USFWS, 2010)
- Continue to emphasize enrollment of large sites under Safe Harbor Agreements, ensuring genetic integrity is maintained and adequate numbers are available for other conservation activities. (USFWS, 2010)

- Pursue a Safe Harbor Agreement or similar tool for the desert pupfish in California. (USFWS, 2010)

Additional Threshold Information:

- Pupfish have an extraordinary ability to survive under conditions of high water temperature (to 45 C, Lowe et al. 1967), low dissolved oxygen concentration (0.1-0.4 milligrams per liter (mg/L), (Barlow 1958b)], and high salinity [salt concentrations twice (68 grams per liter) that of seawater, Lowe et al. 1967], which exceed tolerances of virtually all other freshwater fishes (see also Kinne 1960, Kinne and Kinne 1962 a,b). They also survive abrupt, absolute changes in both salinity (10-15 grams per liter (gm/L)] and temperature (22—260C) (Kinne 1960, Lowe and Heath 1969) that are lethal to most fishes. (USFWS, 1993)
- Pupfish have an extraordinary ability to survive under conditions of high water temperature (to 45 C, Lowe et al. 1967), low dissolved oxygen concentration (0.1-0.4 milligrams per liter (mg/L), (Barlow 1958b)], and high salinity [salt concentrations twice (68 grams per liter) that of seawater, Lowe et al. 1967], which exceed tolerances of virtually all other freshwater fishes (see also Kinne 1960, Kinne and Kinne 1962 a,b). They also survive abrupt, absolute changes in both salinity (10-15 grams per liter (gm/L)] and temperature (22—260C) (Kinne 1960, Lowe and Heath 1969) that are lethal to most fishes. (USFWS, 1993)

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SPECIES ACCOUNT: *Cyprinodon nevadensis mionectes* (Ash Meadows Amargosa pupfish)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; June 5, 1983 (emergency listing rule); September 2, 1983 (final listing rule).

Physical Description

The Ash Meadows Amargosa pupfish is a small chunky fish with several vertical stripes. Females and young fish are olive green to tan in coloration, and males have a blueish tint that is more vibrant during spawning. Males and females can reach up to 6 centimeters (cm) (2.3 inches [in.]) in length, but are generally less than 5 cm (2 in.) (USFWS 2015).

Taxonomy

The Ash Meadows Amargosa pupfish is a subspecies of C. nevadensis. The Ash Meadows Amargosa pupfish was first described in 1998, and there have been no changes in taxonomic classification since. Studies have determined that the Ash Meadows Amargosa pupfish is genetically distinct from other fish that share the same ancestor. The Ash Meadows Amargosa pupfish differs in profile, having a deep and slab-sided body with a greatly arched and compressed predorsal profile; a very long head and opercle; and less-than-average body size and finray and scale counts.

Historical Range

The Ash Meadows Amargosa pupfish was historically found in 10 spring systems throughout the Ash Meadows area of Amargosa Valley in Nye County, Nevada (USFWS 2015).

Current Range

Currently, the Ash Meadows Amargosa pupfish is known from the Ash Meadows National Wildlife Refuge. Most of the major spring systems in this refuge are designated as critical habitat (USFWS 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/2/1983.

Legal Description

On September 2, 1983 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Cyprinodon nevadensis mionectes (Ash Meadows Amargosa pupfish) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes nine critical habitat unit (CHUs) in Nevada (48 FR 40178-40186).
The critical habitat designation for Cyprinodon nevadensis mionectes includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special

management or protection. The Service determined that no additional areas were essential to the conservation of Cyprinodon nevadensis mionectes.

Critical Habitat Designation

The critical habitat designation for Cyprinodon nevadensis mionectes includes nine CHUs in Nye County, Nevada (48 FR 40178-40186).

Nevada, Nye County: Each of the following springs and outflows plus the surrounding land areas for a distance of 50 meters (164 feet) from these springs and outflows:

(1) Fairbanks Spring and its outflow to the boundary between sections 9 and 10, T17S, R50E.

(2) Rogers Spring and its outflows to the boundary between Sections 15 and 16, T17S, R50E.

(3) Longstreet Spring and its outflow to the boundary between Sections 15 and 22, T17S, R50E.

(4) Three unnamed springs in the northwest corner of Section 23, T17S, R50E, and each of their outflows for a distance of 75 meters (246 feet) from the spring.

(5) Crystal Pool and its outflow for a distance of 400 meters (1,312) feet from the pool.

(6) Bradford Springs in Section 11, T18S, R50E, and their outflows for a distance of 300 meters (984 feet) from the springs.

(7) Jack Rabbit Spring and its outflow flowing southwest to the boundary between Section 24, T18S, R50E and Section 19, T18S, R51E.

(8) Big Spring and its outflow to the boundary between Section 19m T18S, R51E and Section 24, T18S, R50E.

(9) Point of Rocks Springs and their entire outflows within Section 7, T18S, R51E.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (48 FR 40178-40186):

(1) Known constituent elements include warm-water springs and their outflows and surrounding land areas that provide vegetation for cover and habitat for insects and other invertebrates on which the species feeds.

Life History

Feeding Narrative

Adult: Ash Meadows Amargosa pupfish feed primarily on periphyton and algae, but they will also eat invertebrates, detritus, and diatoms. Invasive species can out-compete the pupfish for food. Riparian communities provide important inputs to the nutrients and food sources.

Reproduction Narrative

Adult: Female Ash Meadows Amargosa pupfish release eggs and males fertilize them (spawning). Eggs then hatch and the fish mature in the same pool where they were hatched. The entire life cycle of the Ash Meadows Amargosa pupfish occurs in one pool. The Ash Meadows Amargosa pupfish have a lifespan that varies depending on the pool temperature. Sexual maturity is also variable in the species, depending on water temperate (2 to 4 months until sexual maturity in warm waters and up to a year in cold water). Spawning usually occurs in water temperatures between 25 and 31 C° (77 and 88 F°) in spring, but can occur from April to October. If the water is warm enough, breeding can occur year-round. Pupfish can live up to 4 years if they are found in a cooler water temperature environment, but Ash Meadows Amargosa pupfish often live only up to 1 or 2 years.

Geographic or Habitat Restraints or Barriers

Adult: Ash Meadows Amargosa pupfish are restricted to riverine habitats. Habitat destruction has isolated subpopulations and has caused a genetic bottleneck in some populations (USFWS 2010).

Spatial Arrangements of the Population

Adult: The distribution of the Ash Meadows Amargosa pupfish includes nearly all of the surface waters in the Ash Meadows Refuge, inholdings, and adjacent land in the Amargosa Valley in Nye County, Nevada. Even though the Ash Meadows Armargosa pupfish is found throughout Ash Meadows refuge, habitat destruction has caused the different pools in Ash Meadows to be separated. This has also separated the Ash Meadows Amargosa pupfish populations so that genetic mixing is limited. The small Ash Meadows Amargosa pupfish populations mate only with pupfish found in their own pool, resulting in genetic bottlenecking (USFWS 2010).

Environmental Specificity

Adult: Moderate

Tolerance Ranges/Thresholds

Adult: Moderate. Highly eurythermal. Ash Meadows Amargosa pupfish can tolerate temperatures from 2 to 44° C (35.6 to 111.2°F). Tolerance for egg development is much narrower, and feeding and breeding do not occur at extreme temperatures (USFWS 2010). Ash Meadows Amargosa pupfish are susceptible to low pH and have a moderate tolerance for salinity in their pools (USFWS 2010).

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: None

Habitat Narrative

Adult: Ash Meadows Armargosa pupfish live in shallow or deep thermal pools and streams associated with springs (USFWS 2010). Riparian communities adjacent to the pools provide important allochthonous inputs that benefit the pupfish. The distribution of the Ash Meadows Amargosa pupfish includes nearly all of the surface waters in the Ash Meadows Refuge, inholdings, and adjacent land in the Amargosa Valley in Nye County, Nevada. Habitat destruction has isolated subpopulations and has caused a genetic bottleneck in some populations (USFWS 2010). The species is highly eurythermal and can tolerate temperatures ranging from 2 to 44° C (35.6 to 111.2°F). At extreme temperatures, tolerance for egg development is much narrower, and feeding and breeding does not occur (USFWS 2010).

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low dispersal.

Immigration/Emigration

Adult: Does not immigrate/emigrate.

Dependency on Other Individuals or Species for Dispersal

Adult: Not applicable.

Dispersal/Migration Narrative

Adult: Ash Meadows Amargosa pupfish do not migrate. Historically, Ash Meadows Amargosa pupfish were able to genetically mix with other Ash Meadows Amargosa pupfish populations. Due to habitat destruction, Ash Meadows Amargosa pupfish are now often limited to specific pools, causing low species dispersal.

Additional Life History Information

Adult: Not applicable.

Population Information and Trends

Population Trends:

The Ash Meadows Amargosa pupfish population is slightly decreasing—except in Crystal Springs, which is increasing.

Species Trends:

Decreasing

Population Growth Rate:

Declining

Number of Populations:

No information available.

Population Size:

1,000 to 10,000 individuals. Most likely the population is around 5,000 individuals (NatureServe 2015).

Minimum Viable Population Size:

No information available.

Resistance to Disease:

Ash Meadows Amargosa pupfish are resistant to native diseases, bacteria, and pathogens. There are threats to the Ash Meadows Amargosa pupfish due to nonnative species that introduce diseases to which the pupfish is not adapted.

Adaptability:

Moderate

Additional Population-level Information:

Population levels are highly variable, changing 10 to 20 times in the course of a year.

Population Narrative:

Ash Meadows Amargosa pupfish (Cyprinodon nevadensis mionectes) are endangered primarily due to habitat destruction. About 1,000 to 10,000 individuals remain in different pools across the Ash Meadows Refuge, and populations are continuing to decline (NatureServe 2015, USFWS 2010).

Threats and Stressors

Stressor: Habitat destruction (agriculture, development, and mining)
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Ash Meadows Amargosa pupfish live in pools that provide most of the usable surface water (for human use) in the area where they are found. Habitats have been dramatically altered by agricultural development that uses this surface water. Ash Meadows Amargosa pupfish habitat has been altered by diversion of water into earthen or concrete channels; impoundments; drying due to pumping of local groundwater; and elimination of riparian vegetation during ground leveling. The species disappeared from Jackrabbit and Forest springs when the springs were dried and pumped and their morphology was severely altered. Calvada Lake, springs, and outflows were altered when land was cleared for roads, irrigation, and parks; this eliminated portions of Ash Meadows Amargosa pupfish population (USFWS 1990). In the 1960s, 2,000 acres of upper Carson Slough were mined for peat, eliminating one of the largest marshes in southern Nevada and many of the area’s pupfish (USFWS 1990, USFWS 2010). Destruction of terrestrial riparian communities harms pupfish because it reduces the amount of allochtonous material that provides food to the pupfish, and can cause Ash Meadow Amargosa pupfish habitat to become nutrient-poor (USFWS 2010).

Stressor: Introduced species
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.

Narrative: Nonnative predatory and competing aquatic species have been introduced in some of the Ash Meadows Amargosa pupfish habitat. Nearly all nonnative aquatic species predate on eggs, larvae, or adult Ash Meadows Amargosa pupfish. Juveniles and adult pupfish are also predated on by nonnative bullfrogs and crayfish. Nonnative aquatic species compete with the Ash Meadows Amargosa pupfish for food and resources. Invasive species have also introduced disease and parasites to which the Ash Meadows Amargosa pupfish are not adapted or immune, resulting in decline in fitness or death. Introduced vegetation around Ash Meadows Amargosa pupfish pools has resulted in increased fire intensities; an increase in areas of vegetation cover that were historically open water; and out-competition of native plants, degrading the surrounding ecosystem (USFWS 2010).

Stressor: Groundwater development
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Groundwater withdrawal takes water out of the Ash Meadows Amargosa pupfish habitat and limits the amount of water in each pool. This is especially problematic because these effects are not immediately obvious, and can be masked by events such as precipitation. Changes in groundwater flow and elevation to Ash Meadows Amargosa pupfish pools can also affect the temperature and chemical content of the pool, resulting in conditions to which Ash Meadows Amargosa pupfish is not adapted (USFWS 2010).

Recovery

Reclassification Criteria:
All nonnative animals and plants must be eradicated from essential habitat. These nonnative species currently include sailfin mollies, mosquitofish, largemouth bass, black bullheads, bullfrogs, crayfish, turban snails, wild horses, salt cedar, and Russian olive.

Secure and protect the Ash Meadows aquifer so that all spring flows return to historic discharge rates, and the water level in Devil's Hole is maintained at a minimum level of 1.4 feet below the copper washer. Spring discharge rates will be determined by Task number 211.

Reestablish water to historic springbrook channels, free of barriers that eliminate genetic exchange between populations by preventing movement of native fishes throughout their historic range.

The essential habitat must be secure from detrimental human disturbances, including mining, off-road vehicles, and introduction of nonnative species.

All listed fish species are present in all the springs they have historically occupied, as identified in Appendix A, Table XIII.

No information available.

Delisting Criteria:
To delist Ash Meadows Amargosa pupfish, all reclassification criteria must be met.

Secure, protect, and maintain in natural vegetation, corridors, and adjacent buffer areas for gene flow and dispersal of listed plant species in the essential habitat.

Native plant communities and aquatic communities have been reestablished to historic structure and composition in all essential habitat.

Each individual spring or stream population of Ash Meadows Amargosa pupfish has sex ratios and juvenile-to-adult ratios that support self-sustaining populations as determined by Task 626 (in recovery plan).

No information available.
No information available.

Recovery Actions:
- Secure and protect land and water.
- Manage area of Management Concern land and water.
- Manage Devil's Hole.
- Manage lands under the jurisdiction of the Bureau that are within Ash Meadows essential habitat but outside the Area of Management Concern.
- Manage private lands that are in the essential habitat but outside of the Area of Management Concern.
- Investigate biological factors affecting recovery.
- No information available.

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS: (optional, but may be helpful to identify priorities for management actions and information needs for next 5-year review) 1. Monitor compliance with Nevada Revised Statute Order 1197A (January 12, 2018), Curtailment of New Appropriations of Groundwater within the Amargosa Valley Hydrographic Basin 230, that prohibits new applications for water or water diversions within 25 miles of Devils Hole (and by proximity Ash Meadows NWR). Water levels in Devils Hole are affected by pumping centers in the Amargosa Desert and the Ash Meadows groundwater basins (Halford and Jackson 2020). 2. Collaborate with the Ash Meadows NWR to implement the Desert National Wildlife Refuge Complex – Ash Meadows, Desert, Moapa Valley, and Pahranagat National Wildlife Refuges Final Comprehensive Conservation Plan and Environmental Impact Statement, Volume I – August 2009 (Service 2009) and also the Draft Ash Meadows Natural Resource Management Plan in review (Service, in review); and 3. Support Ash Meadow Amargosa pupfish research at the Ash Meadows NWR to monitor the population as identified in the Recovery Plan for the Endangered and Threatened Species of Ash Meadows (Service 1990); and 4. Monitor the future activity of mineral rights in the Ash Meadows area. The BLM ACEC surrounding the refuge is withdrawn from mining and entry until 2029 (PLO# 7737, signed November 2nd, 2009), but requires renewal every 20 years. Mining can still occur on private inholdings within the refuge, but no active mining permits exist at this time. (USFWS, 2020)

Additional Threshold Information:
- No information available.
- No information available.

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Not applicable.

USFWS. 2020. 5-YEAR REVIEW Ash Meadows Amargosa pupfish (Cyprinodon nevadensis mionetes). 6 pp.

SPECIES ACCOUNT: *Cyprinodon nevadensis pectoralis* (Warm Springs pupfish)

Species Taxonomic and Listing Information

Listing Status: Endangered; October 13, 1970 (35 FR 16047).

Physical Description

Adult Warm Springs pupfish reach 6 centimeters (2.4 inches) in length (NatureServe 2015). They are predominately silver in color, sometimes with a black tip on their caudal fin. They typically have 17 pectoral rays, a greater number than other subspecies of C. nevadensis, and show a tendency toward reduction and loss of pelvic fins (USFWS 1976).

Taxonomy

The Warm Springs pupfish is the smallest of six subspecies in the C. nevadensis complex; it is primarily distinguished by its 17 pectoral fin rays, a greater number than is found in other subspecies of C. nevadensis (USFWS 1990). Two members of the subspecies are considered to be extinct (USFWS 1976). Of the extant subspecies, the Warm Springs pupfish has the most localized distribution and maintains the smallest populations (USFWS 1976).

Historical Range

The Warm Springs pupfish is endemic to the Amargosa River drainage in southwestern Nye County, Nevada; and adjacent positions of Inyo and San Bernadino counties, California (USFWS 1976).

Current Range

The Warm Springs pupfish occupies six small springs in an area encompassing less than 1.99 square kilometers (0.77 square mile), situated approximately 1 kilometer (0.62 mile) west of Devil's Hole in Ash Meadows, Nye County, Nevada (USFWS 1990).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Juvenile: See adult life stage.

Adult: Warm Springs pupfish are opportunistic omnivores that feed on insects and plant matter. Because their habitat is limited to springs, the distribution of their food is also limited to springs. They experience resource competition from nonnative mosquitofish, which can threaten the viability of Warm Springs pupfish populations (USFWS 1990; USFWS 2014).

Reproduction Narrative

Juvenile: See adult life stage.

Adult: Warm Springs pupfish begin spawning at the end of February and continue through October, with a peak in spawning activity between April and June (USFWS 1990; USFWS 2014). Breeding males become iridescent blue in color and defend their breeding territories, chasing away all other fish except females that are ready to spawn (USFWS 2014). Water temperatures above 18°C (64°F) are optimal for breeding, and Warm Springs pupfish use shallow shoreline habitat as reproductive territory (USFWS 1976). There is typically an increase in the number of juvenile Warm Springs pupfish during May, June, and July, and juvenile Warm Springs pupfish can develop to reproductive maturity in as little as 2 to 3 months (USFWS 1976; USFWS 2014). The average life span of Warm Springs pupfish is 6 to 9 months, though some survive for more than 1 year (USFWS 2014).

Geographic or Habitat Restraints or Barriers

Juvenile: All of its habitats are isolated from other aquatic environments (USFWS 1990).

Adult: All of its habitats are isolated from other aquatic environments (USFWS 1990).

Spatial Arrangements of the Population

Juvenile: Random

Adult: Random

Environmental Specificity

Juvenile: Broad/generalist

Adult: Broad/generalist

Site Fidelity

Juvenile: High

Adult: High

Habitat Narrative

Juvenile: See adult life stage.

Adult: Warm Springs pupfish inhabit low-discharge (up to 4.43 liters per second [1.17 gallons per second]), warm (30 to 31°C [86 to 88°F]) freshwater springs and brooks (NatureServe 2015; USFWS 1990). Their aquatic habitats are isolated from other aquatic environments. They are distributed widely in springs, and although the majority of fish reside in source pools and headwaters, they often move to ephemeral outlet streams (USFWS 1976). As temperatures become extreme toward summer, evaporation dries up most pools and streams, resulting in the death of most pupfish. A few survive in the small number of pools, streams, and springs that do not dry up completely (USFWS 2014). Their habitat is threatened by groundwater withdrawal, which has reduced the amount of spring and stream habitat available.

Dispersal/Migration

Motility/Mobility

Juvenile: Moderate; able to move from source pools and headwaters to ephemeral streams.

Adult: Moderate; able to move from source pools and headwaters to ephemeral streams.

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Nonmigratory

Adult: Nonmigratory

Dispersal

Juvenile: None

Adult: None

Immigration/Emigration

Juvenile: No

Adult: No

Dependency on Other Individuals or Species for Dispersal

Juvenile: No

Adult: No

Dispersal/Migration Narrative

Juvenile: See adult life stage.

Adult: Warm Springs pupfish have moderate mobility, because they often move from source pools and headwaters to ephemeral streams. They are nonmigratory and do not disperse or emigrate out of their home pools and streams. Although Warm Springs pupfish survive in outlet streams of all springs, such habitat is extremely marginal, with little or no reproduction occurring. Consequently, the physically stable source pools or headwaters are critical to the survival of these populations (USFWS 1976).

Additional Life History Information

Juvenile: Although Warm Springs pupfish survive in outlet streams of all springs, such habitat is extremely marginal, with little or no reproduction occurring. Consequently, the physically stable source pools or headwaters are critical to the survival of these populations (USFWS 1976).

Adult: Although Warm Springs pupfish survive in outlet streams of all springs, such habitat is extremely marginal, with little or no reproduction occurring. Consequently, the physically stable source pools or headwaters are critical to the survival of these populations (USFWS 1976).

Population Information and Trends

Population Trends:

Stable, although population size naturally fluctuates dramatically on an annual timeline (USFWS 1990).

Species Trends:
Stable (USFWS 1990)

Population Growth Rate:
Stable

Number of Populations:
6

Population Size:
136 to 231 individuals in School Spring from November 1972 to 1974. Populations in all six springs are believed to be small (USFWS 1990). Population size at present is estimated between 1 and 2,500 individuals (NatureServe 2015).

Resistance to Disease:
Low

Population Narrative:
The U.S. Fish and Wildlife Service classified Warm Springs pupfish as a stable subspecies in 1990. The six extant populations are also stable, although their numbers naturally fluctuate dramatically throughout the course of a year. All populations are believed to be small due to limited available habitat; there were estimated to be between 136 to 231 individuals in School Spring from November 1972 to 1974 (USFWS 1990). Population size at present is estimated between 1 and 2,500 individuals (NatureServe 2015).

Threats and Stressors

Stressor: Competition and predation by nonnative mosquitofish (Gambusia affinis), crayfish (Procambarus clarkii), and bullfrogs (Rana catesbeiana).
Exposure: Nonnative competitors and predators.
Response: Reduced food availability and increased predation.
Consequence: Declining populations.
Narrative: Nonnative mosquitofish (Gambusia affinis) may adversely impact Warm Springs pupfish through competition for food and space. Bullfrogs (Rana catesbeiana) and crayfish (Procambarus clarkii) can reduce the population size of Warm Springs pupfish through predation, especially through predation of young (USFWS 1976; USFWS 1990).

Stressor: Agricultural and Residential Development.
Exposure: Groundwater withdrawal.
Response: Lowering of water table.
Consequence: Reduction in available habitat.
Narrative: Agricultural and residential development have caused water levels to drop, resulting in the lowering of the water table. This has reduced the amount of available habitat for Warm Springs pupfish, although this threat has been reduced with the establishment of the Ash Meadows National Wildlife Refuge (NatureServe 2015).

Stressor: Low population numbers.
Exposure: Few individuals.
Response: Vulnerability to inbreeding, catastrophes, and random events.
Consequence: Increased risk of extirpation or extinction.
Narrative: The low numbers of Warm Springs pupfish in its isolated habitats naturally make it vulnerable to risks associated with small, restricted populations. The elements of risk that are amplified in very small populations include: (1) random demographic events (e.g., skewed sex ratios, high death rates, or low birth rates); (2) the effects of genetic drift (random fluctuations in gene frequencies) and inbreeding (mating among close relatives); (3) natural catastrophes (floods, fires, droughts, etc.) at random intervals; and (4) deterioration of environmental quality (USFWS 1976).

Recovery

Reclassification Criteria:
The following conditions must be met within essential habitat for a period of 5 years:

All nonnative animals and plant species must be eradicated from essential habitat. These nonnative species currently include sailfin mollies, mosquitofish, largemouth bass, black bullheads, bullfrogs, crayfish, turban snails, wild horses, saltcedar, and Russian Olive.

Secure and protect the Ash Meadows aquifer so that all spring flows return to historic discharge rates, and the water level in Devil's Hold is maintained at a minimum level of 0.43 meter (1.4 feet) below the copper washer.

Reestablish water to historic springbrook channels which are free of barriers that eliminate genetic exchange between populations by preventing movement of native fishes throughout their historic range.

The essential habitat must be secure from detrimental human disturbances, including mining, off-road vehicles, and introduction of nonnative species.

All listed fish species are present in all the springs that they have occupied historically.

Delisting Criteria:
In addition to meeting the Reclassification Criteria, the following conditions must be met for a period of 5 years:

Secure, protect, and maintain in natural vegetation, corridors, and adjacent buffer areas for gene flow and dispersal of listed plant species in the essential habitat.

Native plant communities and aquatic communities have been reestablished to historic structure and composition in all essential habitat.

Each individual spring or stream population of Warm Springs pupfish have sex ratios and juvenile-to-adult ratios that support self-sustaining populations.

Recovery Actions:

- Secure and protect land and water. Acquire and protect land and water within the Area of Management Concern by securing and protecting Devil's Hole; withdrawing Bureau lands; securing private lands; protecting subsurface waters and acquiring and protecting surface waters; acquiring mineral rights; and posting refuge notification for the public. Secure and protect lands and surface and groundwater outside the Area of Management Concern but within Ash Meadows essential habitat by securing and protecting critical habitats (including Bureau-managed lands and private lands) and securing and protecting subsurface and surface waters.
- Manage Area of Management Concern lands and water. Return spring flow to historic channels by determining historic spring flow channels and discharge rates, and by developing and implementing a water-flow restoration plan. Enhance and/or restore terrestrial ecosystems by determining historic plant communities and distributions (by preparing current vegetation maps and preparing a historic plant communities map); removing introduced nonnative plant species (by determining appropriate control methods, scheduling and completing initial eradication of introduced nonnative plant species, and scheduling periodic control to prevent reestablishment of saltcedar and/or Russian olive); preventing reestablishment of wild horse herds; enhancing and/or reestablishing native plant communities; and reestablishing seven listed plant species throughout historic habitats. Enhance and/or restore aquatic ecosystems by determining historic aquatic animal communities and their distributions; removing nonnative competitive/predatory aquatic species (by determining appropriate methods for removal, scheduling and completing eradication of nonnative aquatic species, and scheduling periodic control to prevent reestablishment of nonnative aquatic species); reestablishing native aquatic communities; and reestablishing four listed fish throughout their historic range. Minimize human disturbance. Monitor enhanced/reestablished populations every 2 years, and determine factors controlling population size.
- Manage Devil's Hole. Monitor habitat conditions by monitoring water levels, chemistry, and physical properties; monitoring algae and invertebrates; and recommending maintenance measures as suggested by monitoring program. Restore and maintain natural conditions by establishing interim minimum water level of 0.82 meter (2.7 feet) pending return to natural level of 0.43 meter (1.4 feet), seeking injunctions or cease and desist orders during emergency threats, performing maintenance as required, minimizing human disturbance, and posting informational signs at Devil's Hole.
- Manage lands that are under the jurisdiction of the Bureau that are within Ash Meadows essential habitat but outside the Area of Management Concern. Schedule and complete initial eradication of introduced nonnative plant species, schedule periodic control to prevent reestablishment of saltcedar, prevent reestablishment of wild horse herds, minimize human disturbance, monitor colonies of five listed plant species, monitor as appropriate for each species and its life history, and determine factors controlling population size.
- Manage private lands that are in the essential habitat but outside of the Area of Management Concern. Identify land ownership and pursue appropriate protective management measures.
- Investigate biological factors affecting recovery. Determine historically and presently occupied habitats; determine ecology of four fishes, including spawning habitats, rearing habitats, adult habitats, age and growth, food and feeding, reproduction and fecundity,

associations with exotic species, and interspecific interactions. Determine population and habitat reconstruction goals for reclassification/delisting as appropriate, by determining the amount and location of areas needed to support self-sustaining populations, determining population demography criteria, and incorporating findings into management and recovery plans.

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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: 1. Monitor compliance with Nevada Revised Statute Order 1197A (January 12, 2018), Curtailment of New Appropriations of Groundwater within the Amargosa Valley Hydrographic Basin 230, that prohibits new applications for water or water diversions within 25 miles of Devils Hole (and by proximity to AMNWR). Water levels in Devils Hole, and concomitantly, spring flows at AMNWR, are affected by pumping centers in the Amargosa Desert and the Ash Meadows groundwater basins (Halford and Jackson 2020). 2. Collaborate with the AMNWR to implement the Desert National Wildlife Refuge Complex – Ash Meadows, Desert, Moapa Valley, and Pahranagat National Wildlife Refuges Final Comprehensive Conservation Plan and Environmental Impact Statement, Volume I – August 2009 (Service 2009) and also the Draft Ash Meadows Natural Resource Management Plan in review (Service, in review); and 3. Support Ash Meadow Amargosa pupfish research at the AMNWR to monitor the population as identified in the Recovery Plan for the Endangered and Threatened Species of Ash Meadows (Service 1990); and 4. Monitor the future activity of mineral rights in the Ash Meadows area. The BLM ACEC surrounding the refuge is withdrawn from mining and entry until 2029 (PLO# 7737, signed November 2nd, 2009), but requires renewal every 20 years. Mining can still occur on private inholdings within the refuge, but no active mining permits exist at this time.

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SPECIES ACCOUNT: *Cyprinodon radiosus* (Owens pupfish)

Species Taxonomic and Listing Information

Listing Status: Endangered; March 11, 1967 (32 FR 4001).

Physical Description

The Owens pupfish (Cyprinodon radiosus) is a small, deep-bodied, laterally-compressed fish in the killifish family (Cyprinodontidae); it has a highly arched back and an upturned mouth (BLM 2011; USFWS 2009). The total length of the Owens pupfish rarely exceeds 6 centimeters (2.5 inches) (USFWS 1998; USFWS 2009). The species is sexually dimorphic (males and females can easily be distinguished from each other by coloration). Females are a dusky olive green, with several dark vertical bars aligned in a row along the sides (USFWS 1998). Males are bright blue, particularly during the spring and summer spawning season (USFWS 1998).

Taxonomy

The Owens pupfish is distinguished from other pupfishes by the anterior placement of its dorsal fin, its long caudal peduncle (the narrow part of a fish's body to which the caudal or tail fin is attached), the absence of spine-like projections on scale circuli (growth rings), and the absence of a terminal black band on the caudal fin. The number of rays in its dorsal, pelvic, pectoral, and anal fins is also greater than other species. The desert pupfish (C. macularius) of the lower Colorado River system is the closest relative of the Owens pupfish. Ancestral pupfish probably entered the Owens Basin through the Death Valley region during the Pleistocene, when waters of the Colorado River and Death Valley system were connected (USFWS 1998).

Historical Range

The Owens pupfish was historically restricted to the Owens Valley portion of the Owens River in Mono and Inyo counties, California. Owens pupfish were once common throughout the Owens River, occurring in clear waters of springs, sloughs, irrigation ditches, swamps, and flooded pastures from Fish Slough in Mono County, south to Lone Pine in Inyo County (USFWS 2009).

Current Range

In July 1964, a single population of approximately 200 fish was rediscovered in Fish Slough (USFWS 1998). All extant populations have been propagated from this remnant stock (USFWS 1998). Extant populations occur only in refuges at Fish Slough (which contains the Bureau of Land Management [BLM] Spring, BLM Ponds, and Marvin's Marsh sub-populations), Mule Springs, Well 368, and Warm Springs (USFWS 2009). All of these habitats are managed to protect Owens pupfish by isolating them from nonnative fishes (USFWS 1998).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Juvenile: See Adult narrative.

Adult: Owens pupfish are opportunistic omnivores that primarily eat invertebrates (including midge larvae, mayfly larvae, and beetle larvae and adults). Their diet also includes small crustaceans, terrestrial insects that fall into the water, algae, carrion, and fish eggs. Owens pupfish have been shown to be effective in controlling mosquito larvae (NatureServe 2015). The diet of Owens pupfish changes seasonally, typically including invertebrates and those plants most abundant in the environment (USFWS 1998).Four omnivorous species comprise the Owens Basin native fish assemblage: the Owens pupfish, Owens tui chub (Gila bicolor snyderi), Owens speckled dace (Rhinichthys osculus robustus), and Owens sucker (Catostomus fumeiventris). None of the native fishes prey on other fishes, and there is likely little interaction among native members of the Owens Basin assemblage (USFWS 1998). However, Owens pupfish experience predation and competition from introduced species, including largemouth bass (Micropterus salmoides), smallmouth bass (Micropterus dolomieu), brown trout (Salmo trutta), bluegill (Lepomis macrochirus), mosquitofish (Gambusia affinis), crayfish (Pastifasticus leniusculus), and bullfrogs (Rana catesbeiana) (USFWS 2009).

Reproduction Narrative

Juvenile: See Adult narrative.

Adult: Sexually mature Owens pupfish breed between April and October (BLM 2011). Females begin producing eggs when water temperatures are near 14°C (57°F) (USFWS 1998). Male pupfish are territorial, defending open areas close to shore from competing males (USFWS 1998); female Owens pupfish swim in schools along the margins of areas defended by males. Females choose males for mating (BLM 2011; USFWS 1998); when a female is attracted to a male, she leaves the school to spawn over silty bottoms, submerged plants, algal clumps, rocks, or crevices at depths of up to 2 m (6.5 ft.) (BLM 2011; NatureServe 2015). Female Owens pupfish may be involved in spawning acts as many as 200 times per day, but they lay only one to two eggs at a time (USFWS 2009).Eggs incubate for approximately 6 days before hatching in water temperatures ranging from 24°C to 27°C (75°F to 81°F), with an average of 95 percent of spawned eggs fertilized (USFWS 2009). Juvenile pupfish grow rapidly to sexual maturity, in 3 to 4 months. They are usually able to spawn before their first winter (USFWS 1998). Owens pupfish rarely live longer than 1 year, although some individuals have been observed living as long as 3 years in refuge habitats (USFWS 1998).

Geographic or Habitat Restraints or Barriers

Juvenile: Lack of habitat connectivity in currently occupied sites (USFWS 2009).

Adult: Lack of habitat connectivity in currently occupied sites (USFWS 2009).

Spatial Arrangements of the Population

Juvenile: Clumped; Owens pupfish congregate in small schools (USFWS 2009). Juveniles occupy more shallow waters than do adults, but all life stages use many microhabitats available in the environment with little preference (USFWS 1998).

Adult: Clumped; Owens pupfish congregate in small schools (USFWS 2009). Adults frequently occupy deeper waters; but all life stages use many microhabitats available in the environment, with little preference (USFWS 1998).

Environmental Specificity

Adult: Broad/generalist (USFWS 1998).

Tolerance Ranges/Thresholds

Adult: High; Owens pupfish live in desert areas and can survive exposure to high temperatures. During the summer months, the average water temperature is around 100°F (38°C), and can reach as high as 116°F (47°C). They can survive in water temperatures as low as 32°F (0°C); in salinities that are four times greater than the salt content of ocean water; and in water with very little oxygen (BLM 2011).

Site Fidelity

Adult: Low

Habitat Narrative

Juvenile: See Adult narrative.

Adult: Owens pupfish occur in small schools in freshwater low-gradient creeks and springs (USFWS 1998; USFWS 2009). They can occupy most aquatic habitat with silt- or sand-covered creek bottom where the water is warm and food is plentiful (NatureServe 2015; USFWS 1998). Juveniles tend to occupy water habitats that are shallower than those occupied by adults; but all life stages use many microhabitats available in the environment with little preference (USFWS 1998). The valley floor in Owens Basin contains wetland vegetation that is dominated by sedges (Cyperaceae) and grasses (Poaceae); and riparian vegetation that is dominated by willows (Salix sp.) (USFWS 1998). Owens pupfish are threatened by cattail (Typha sp.) encroachment, but control measures are being taken to prevent habitat loss (USFWS 2009). Owens pupfish are typically a highly mobile species, but the sites they currently occupy consist of manmade ponds and marshes that are disconnected from larger bodies of water, and therefore dispersal is restricted (USFWS 2009).Owens pupfish live in desert areas and can survive exposure to a wide range of temperatures, salinities, and oxygen levels. During the summer months, the average water temperature is around 100°F (38°C), and can reach as high as 116°F (47°C) (BLM 2011). Aquatic habitats in the Owens Basin are frequently covered by ice during the winter, and Owens pupfish can survive in water temperatures as low as 32°F (0°C) (BLM 2011; USFWS 1998). Owens Basin aquatic habitats also have conductivity and salinity lower than those of habitats occupied by pupfishes in other regions in North American deserts, but the Owens pupfish can survive in salinities that are four times greater than the salt content of ocean water (BLM 2011; USFWS 1998).

Dispersal/Migration

Motility/Mobility

Adult: High; highly mobile (USFWS 1998).

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: High; in its natural habitat, the Owens pupfish rapidly invades vacant habitats (USFWS 1998).

Immigration/Emigration

Adult: Immigrates/emigrates; in its natural habitat, the Owens pupfish rapidly invades vacant habitats (USFWS 1998).

Dependency on Other Individuals or Species for Dispersal

Juvenile: No

Adult: No

Dispersal/Migration Narrative

Juvenile: See Adult narrative.

Adult: Owens pupfish are nonmigratory, but were highly mobile in their native environment, and could rapidly invade vacant habitats, leading to high rates of dispersal and immigration/emigration (USFWS 1998). Construction of aqueducts in the Owens Valley greatly reduced surface water and groundwater, eliminating almost all Owens pupfish habitat. After the only known population was discovered in 1964, some individuals from that population were moved to new locations to create the four populations that exist today. These four populations occur in spring-fed ponds and manmade marshes and ponds that are largely disconnected from other water sources, thus limiting dispersal and emigration (USFWS 2009).

Additional Life History Information

Adult: In their native habitats, Owens pupfish were able to disperse and emigrate quickly. Construction of aqueducts in the Owens Valley greatly reduced surface water and groundwater, eliminating almost all Owens pupfish habitat. After the only known population was discovered in 1964, some individuals from that population were moved to new locations to create the four populations that exist today. These four populations occur in spring-fed ponds and manmade marshes and ponds that are largely disconnected from other water sources, thus limiting dispersal and emigration (USFWS 2009).

Population Information and Trends

Population Trends:

Varies: Warm Springs is increasing; BLM Springs, BLM Ponds, Mule Springs, and Well 368 are considered stable; Marvin's Marsh appears to be declining (USFWS 2009).

Species Trends:

Long-term: decline of greater than 90 percent; short-term: stable (less than 10 percent change) (USFWS 1998; NatureServe 2015).

Number of Populations:

Six (USFWS 2022).

Population Size:

Individual population estimates range from 100-10,000 (USFWS, 2022).

Resistance to Disease:

Low

Additional Population-level Information:

The four populations of Owens pupfish that exist today were established between 1969 and 1995. These populations exist in spring-fed ponds and manmade marshes and ponds (USFWS 2009).

Population Narrative:

There are currently six extant populations of Owens pupfish within Owens Valley, Mono and Inyo Counties, California (Figures 1 and 2). Five of these (BLM Spring, BLM Letter Ponds, Marvins Marsh, Mule Springs, and Well 368) were present when the CDFW Status Review published in March 2020 (Figure 1). Since then, another population of Owens pupfish has been established at the River Spring Lakes Ecological Reserve (RSLER) in Mono County, California (Figure 2). To establish this new population, pupfish were sourced from the five other extant populations and translocated to the approximately 650-acre (264-hectare) reserve. Three of the Owens pupfish populations are located within Fish Slough: BLM Spring, BLM Letter Ponds, and Marvins Marsh. The population at BLM Spring is estimated to be 1,000–10,000 individuals but stable. However, this population fluctuates due to the sporadic introduction of nonnative predator fish such as largemouth bass (Micropterus salmoides). While the source of the introductions is unknown, largemouth bass are detected within BLM Spring multiple times a year. The removal of non-native predators is conducted by CDFW staff as needed. The population at the BLM Letter Ponds is stable and is approximately 100–1,000 individuals. The population at Marvins Marsh is approximately 100–1,000 individuals but declining due to desiccation of habitat. Mule Springs is located on BLM property but managed by the CDFW. This the smallest occupied habitat, consisting of only 0.01 surface acres (0.01 hectares) of artificial habitat. The habitat is a single small plastic-lined pool that requires routine removal of emergent vegetation. Although Mule Springs is entirely artificial, the Mule Springs population is the second largest with approximately 3,000 individuals (CDFW 2020). Well 368 is an artesian well located on LADWP-owned property. Owens pupfish occupy the outflow of the well and total habitat is about 0.05 acres. Owens pupfish were introduced here in 1988 and the population fluctuates between approximately 100–1,000 individuals and is considered to be stable (USFWS, 2022).

Threats and Stressors

Stressor: Competition and predation by nonnative species
Exposure: Direct; introduction of nonnative predators and competitors.
Response: Increased rates of competition and predation.
Consequence: Decline in abundance.
Narrative: Nonnative predators are a serious threat to the Owens pupfish. At the time of listing in 1967, predation by nonnative fish (e.g., largemouth bass [Micropterus salmoides], smallmouth bass [M. dolomieu], brown trout [Salmo trutta], and bluegill [Lepomis macrochirus]) threatened the species. Since listing, mosquitofish (Gambusia affinis), crayfish (Pastifasticus leniusculus), and bullfrogs (Rana catesbeiana) have been introduced into the pupfish's habitat and are recognized also as threats to the Owens pupfish. Nonnative predators eat young and adult Owens pupfish; they also compete with Owens pupfish for food and habitat. Owens pupfish populations are vulnerable and may be threatened by a single individual predator. Nonnative predators are

currently present in much of the habitat historically occupied by pupfish. Therefore, establishing new populations of Owens pupfish will require reintroductions in locations where nonnative predators can be managed. Management plans for each population will include conditions for management of nonnative predators (USFWS 2009).

Stressor: Small, isolated populations
Exposure: Direct and indirect; small, isolated populations.
Response: Increased risk of inbreeding, loss of genetic diversity, and extinction due to stochastic events.
Consequence: Reduced fitness and increased extinction risk.
Narrative: In 1964, the Owens pupfish was extant in only one site. The significant reduction in the numbers and distribution of Owens pupfish may well have created a genetic bottleneck which, in combination with the subsequent rescue and management practices, may have inadvertently reduced the genetic diversity of current Owens pupfish populations. Species that consist of small populations, such as the Owens pupfish, are recognized as being vulnerable to extinction as a result of stochastic (i.e., random) threats. Such threats that may be important to the Owens pupfish are demographic, genetic, and environmental stochasticity and catastrophic events. Demographic stochasticity refers to random variability in survival and/or reproduction among individuals in a population. Genetic stochasticity results from the changes in gene frequencies caused by the founder effect, random fixation, or inbreeding bottlenecks. Environmental stochasticity is the variation in birth and death rates from one season to the next in response to weather, disease, competition, predation, or other factors external to the population (USFWS 2009).

Stressor: Cattail encroachment
Exposure: Direct and indirect; growth and encroachment of cattails.
Response: Reduced habitat quality through loss of open water habitat and accumulation of detritus.
Consequence: Decline in abundance due to habitat loss and degradation.
Narrative: Currently, all four populations of Owens pupfish are threatened by loss of habitat due to cattail encroachment. California Department of Fish and Wildlife personnel regularly control cattail encroachment at all Owens pupfish population sites to maintain open water. Without this control, the open waterways become clogged with emergent vegetation, and accumulate detritus. Detritus covers and thereby eliminates substrate used by the Owens pupfish for breeding, spawning, and courtship behaviors. Emergent vegetation encroachment also reduces water depth, elevates water temperature, and can result in severe anoxic conditions (USFWS 2009).

Stressor: Climate change (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Increasing temperatures and more extreme weather patterns associated with climate change are likely to negatively affect Owens pupfish, which exist in an already arid region in the “rain shadow” of the Sierra Nevada. Owens pupfish habitats are fed by both aquifers and surface flow, which are dependent on snowmelt for recharge. Experts predict that climate change will lead to a reduction in snowpack throughout much of the Sierra Nevada due to warmer temperatures and a shift in precipitation toward rainfall in late winter and early spring months.

Sierra Nevada snowpack levels are already variable from year to year, with some of the lowest levels in recorded history during the prolonged and severe drought from 2012 to 2016. However, the Owens Valley is at the base of the southernmost portion of the Sierra Nevada where the range attains maximum elevations. Thus, the effects of climate change may be mitigated, at least to some extent, by greater accumulation and retention of snowpack in this portion of the range (Moyle et al. 2015). However, Moyle et al. (2015) determined that other Owens Basin fish taxa; such as Owens speckled dace (Rhinichthys osculus robustus) and Owens sucker (Catostomus fumeiventris), are highly vulnerable to climate change, indicating extinction may occur if measures to counter climate change effects are not taken. Since Owens pupfish are similarly limited to a few populations, it is also likely highly vulnerable to the effects of climate change. Given the area's history of water exportation and competing demands for remaining water supplies to meet agricultural, municipal, recreational, and ecological needs, future climate warming and increased variability and extremity of weather patterns will undoubtedly exacerbate existing challenges (USFWS, 2022).

Stressor: Groundwater pumping (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Groundwater pumping for irrigation and municipal supply in the Owens Basin may result in overdraft of the aquifer in the Tri-Valley region of the Owens Valley Groundwater Basin area, which underlies the Benton, Hammil, and Chalfant valleys in Mono County. Spring discharge in Fish Slough has been declining for the last 80 years at a rate of 16–20 percent per decade (CDFW 2020). Discharge at Northeast spring, located in the northeast portion of Fish Slough, shows a steep decline in outflow, and CDFW estimates it will be dry by 2025 (Figure 3, CDFW 2020). Groundwater monitoring wells to the north of Fish Slough in Chalfant and Hammil Valleys show a multi-decadal decline in groundwater surface elevation (CDFW 2020). Loss of Owens pupfish habitat at Fish Slough was noticeable in 2020 due to the declining discharge at Northwest spring (Figure 3, CDFW 2020). Two of the populations at Fish Slough, BLM Spring and BLM Ponds, were described as stable in 2020 (CDFW 2020). However, the third population at Marvins Marsh was described as declining (USFWS, 2022)

Recovery

Reclassification Criteria:
Reproducing populations of Owens pupfish occupy all potential habitat in three populations in which threats are controlled for five consecutive years. Priority order for establishing populations is as follows: Fish Slough, Warm Springs, and Round Valley (USFWS 1998; USFWS 2009).

The area (i.e., potential habitat) occupied by Owens pupfish should be approximately 3.2 hectares (ha) (8 ac.) at Fish Slough, 2 ha (5.5 ac.) at Warm Springs,* and 2.4 ha (6 ac.) at Round Valley (USFWS 1998; USFWS 2009). *The Recovery Plan and 5-Year Review lists the area as 5.5 ac. (2 ha); however, this conversion is incorrect.

Each existing population of Owens pupfish must have an approved management plan and implementing agreement between the landowner and the U.S. Fish and Wildlife Service (USFWS) (USFWS 1998; USFWS 2009).

Successful establishment of these populations will occur when demography follows an annual pattern in which adult fish numbers dominate spring and autumn populations, and juvenile fish numbers dominate early summer populations, and when the biomass of Owens pupfish exceeds the biomass of deleterious nonnative fish (USFWS 1998; USFWS 2009).

Delisting Criteria:
Populations of Owens pupfish are established as part of self-sustaining native fish assemblages throughout all aquatic habitats in four populations for a period of seven consecutive years during which threats are controlled. Priority order for establishing populations is as follows: Fish Slough, Warm Springs, Round Valley, and Black Rock Conservation Area (USFWS 1998; USFWS 2009).

The area occupied by Owens pupfish in Fish Slough, Warm Springs, and Round Valley should be as listed in Reclassification Criteria, and should be 200 ha (500 ac.) at Blackrock, and 1.6 ha (0.6 ac.) at Southern Owens* (USFWS 1998; USFWS 2009). * The Recovery Plan and 5 Year Review list the area as 0.6 ac. (1.6 ha); however, this conversion is incorrect.

Each existing population must have an approved management plan and implementing agreement between the landowner and the USFWS (USFWS 1998; USFWS 2009).

Successful establishment of these populations will occur when demography follows an annual pattern in which adults dominate spring and autumn populations and juveniles dominate early summer populations; and when the biomass of Owens pupfish exceeds the biomass of deleterious nonnative fish (USFWS 1998; USFWS 2009).

Recovery Actions:
- Maintain Owens pupfish refuges at Fish Slough, Warm Springs, BLM Spring, Mule Spring, and Well #368. Perform habitat maintenance activities as needed (USFWS 1998).
- Initiate Conservation Area management in the Fish Slough Conservation Area by controlling deleterious nonnative fish species; reestablishing native fish assemblages; evaluating livestock grazing practices and modifying as necessary; identifying and restoring or enhancing potentially suitable habitat for rare species that have been degraded by human activities; controlling off-road vehicle use; and protecting spring discharge. Initiate Conservation Area management in the Round Valley Conservation Area by controlling deleterious nonnative species; reestablishing Owens Valley native fish assemblages; determining water management practices necessary to maintain the vigor of the Owens Valley native fish assemblage; and evaluating livestock grazing practices and modifying as necessary. Initiate Conservation Area management in the Blackrock Conservation Area by controlling deleterious nonnative species; reestablishing Owens Valley native fish assemblages and determining water management practices necessary for its maintenance; and evaluating livestock grazing practices and modifying as necessary. Initiate Conservation Area management in the Warm Springs Conservation Area by controlling deleterious nonnative species; reestablishing Owens Valley native fish assemblages; evaluating livestock grazing practices and modifying as necessary; and protecting spring discharge (USFWS 1998).
- Determine rare species distribution, abundance, and habitat requirements; assess baseline conditions at each Conservation Area; conduct management-oriented research on the

dispersal and establishment abilities of nonnative fish and plant species to design effective strategies to control them; and conduct studies to determine habitat requirements for the native fish assemblage (USFWS 1998).

- Delineate Conservation Area boundaries by determining boundary delineation criteria and coordinating boundary delineation with affected private parties and federal, state, and local agencies (USFWS 1998).
- Prepare management plans for Fish Slough, Warm Springs, Round Valley, and Blackrock Conservation Areas (USFWS 1998).
- Implement Conservation Area Management plans in coordination with federal and state agencies and private landowners (USFWS 1998).
- Conduct population and habitat monitoring in Fish Slough, Warm Springs, Round Valley, and Blackrock Conservation Areas; genetic monitoring; and spring discharge monitoring (USFWS 1998).
- Develop and implement an outreach program regarding the status of conservation and recovery efforts, including videotape and slide presentations, brochures and pamphlets, and seminars and/or informal meetings in a public forum; and develop and implement a public education program to educate the public about causes for decline and reduced abundance of Owens Basin rare species, and about future activities that are likely to threaten their existence (USFWS 1998).
- Remove emergent vegetation, eradicate nonnative predators from Warm Springs, and reestablish Owens pupfish in the upper and lower ponds (USFWS 2009).
- Evaluate Round Valley to determine whether it is a suitable location for a population of Owens pupfish (USFWS 2009).
- Develop management plans and implementation agreements for all populations (USFWS 2009).
- Establish a new population of Owens pupfish at Cartago Springs Wildlife Area and Blackrock Waterfowl Management Area (USFWS 2009).
- Conduct population surveys and demographic studies, collect additional genetic samples, and complete genetic analysis. Develop breeding programs based on the results of genetic analysis, to optimize genetic material in all populations of Owens pupfish (USFWS 2009).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS In the 2020 CDFW Status Review (Section VI (B) – Recommendations for Management Activities and Other Recommendations for Recovery of the Species), CDFW provides a number of recommendations which the Service hereby incorporates and recommends as the highest priority actions needed for the recovery of this species. These and an additional recommendation from the Service are discussed below. CDFW Recommendations for Future Actions The CDFW Status Review (2020) outlined the following recovery recommendations, which we hereby adopt: 1. Continue to maintain existing habitat and monitor populations: • Continue routine visual monitoring of occupied pupfish habitats and perform manual removal of emergent vegetation on an as-needed basis. • Continue population monitoring. • Continue visual surveys of BLM Spring to detect non-native fish introductions. 2. Expand existing distribution: • Reintroduce Owens Pupfish to the Owens Valley Native Fish Sanctuary and to Warm Spring (previous refuge habitats). • Prioritize and implement next steps in introducing Owens pupfish into the RSLER. 3. Develop and implement a genetic management plan to guide managed gene-flow between all populations: • Use a genetics management plan to inform Owens Pupfish translocations and for the purposes of potential future mixing of populations to ensure maximum genetic variation in all populations. • Integrate, where warranted and feasible, the findings and recommendations of Finger et al. (2013), including founding new populations composed of 30–50 founders from each of the extant populations and regularly translocating up to ten migrants per generation among stable populations. U.S. Fish and Wildlife Service Recommendations 1. Reevaluate the Owens pupfish Conservation Areas for climate resiliency, long-term viability, and with the 3 R's (resiliency, redundancy, and representation) prioritized to ensure the chosen sites will be those best suited for the introduction and persistence of Owens pupfish (USFWS, 2022).

Additional Threshold Information:

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SPECIES ACCOUNT: *Deltistes luxatus* (Lost River sucker)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; July 18, 1988 (53 FR 27130).

Physical Description

Lost River suckers (Deltistes luxatus) are relatively large fish, up to 0.8 meter (m) (2.6 feet [ft.]) long and 4.5 kilograms (9.9 pounds) in weight, distinguished by an elongate body and sub-terminal mouth with a deeply notched lower lip that is relatively more pilose. They have dark backs and sides that fade to yellow or white on the belly. Lake suckers, such as the Lost River sucker, differ morphologically from other suckers in having terminal or sub-terminal mouths. These species also generally possess numerous branched gill rakers (USFWS 2013a).

Taxonomy

This species is a member of a group of suckers (Family Catostomidae) that predominantly uses lake environments. This species was originally described, in 1879, as being included in the genera Chasmistes luxatus. In 1896, it was placed in the new monotypic genus of Deltistes, which reflects the distinctive triangular gill rakers. Its taxonomy remained uncertain until 1967, when scientists examined fossil material and confirmed that other diagnostic characteristics were consistent with extinct members of the genus (USFWS 2013a). Chasmistes and Deltistes are closely related to the older, more diverse, widespread genus Catostomus; Deltistes has unique triangular gill rakers and a ventral mouth with papillose lips and a terminal mouth (NatureServe 2015). It is now recognized as the only extant member of the genus (USFWS 2013a).

Historical Range

This species is endemic to the Upper Klamath Lake Basin, including the Lost River and Lower Klamath subbasins. It is difficult to know precisely which tributaries and bodies of water this species historically occupied because records are sparse, but Lost River sucker occurred in Upper Klamath Lake, Lower Klamath Lake, Tule Lake, and Clear Lake Reservoir; as well as the major tributaries to these water bodies, including the Sprague River, Wood River, Lost River, Willow Creek, and the Klamath River above Lower Klamath Lake (USFWS 2013a; USFWS 2013b).

Current Range

The Lost River sucker occurs in Upper Klamath Lake and Clear Lake Reservoir (Klamath County, Oregon; and Modoc County, California, respectively) (USFWS 2013b). Currently, the total area of lake habitat available for Lost River sucker is about 32,000 hectares (ha) (79,000 acres [ac.]), of which approximately 80 percent is in Upper Klamath Lake, which covers approximately 26,000 ha (64,000 ac.) (USFWS 2013a). Populations in J.C. Boyle Reservoir (Klamath County, Oregon), and in Iron Gate Reservoir, Copco Reservoir, Sheepy Lake, Lower Klamath Lake, and Tule Lake (all in Siskiyou County, California) were believed to be very small or extirpated. The overall distribution has not changed substantially since listing, but some additional information indicates that a resident population of Lost River suckers may exist in the Sprague River near Beatty, Oregon (USFWS 2013b).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 12/11/2012.

Legal Description

On December 11, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Deltistes luxatus (Lost River sucker) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two critical habitat units (CHUs) in Oregon and California (77 FR 73740-73768).

Critical Habitat Designation

The critical habitat designation for Deltistes luxatus includes two CHUs in Klamath and Lake Counties, Oregon, and Modoc County, California (77 FR 73740-73768).

Unit 1: Upper Klamath Lake Unit, Klamath County, Oregon.

Unit 2: Lost River Basin Unit, Klamath County, Oregon.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Deltistes luxatus critical habitat consists of three components in Oregon and California (77 FR 73740-73768):

(i) Water. Areas with sufficient water quantity and depth within lakes, reservoirs, streams, marshes, springs, groundwater sources, and refugia habitats with minimal physical, biological, or chemical impediments to connectivity. Water must have varied depths to accommodate each life stage: Shallow water (up to 3.28 ft (1.0 m)) for larval life stage, and deeper water (up to 14.8 ft (4.5 m)) for older life stages. The water quality characteristics should include water temperatures of less than 82.4 [deg]Fahrenheit (28.0 [deg]Celsius); pH less than 9.75; dissolved oxygen levels greater than 4.0 mg per L; low levels of microcystin; and un-ionized ammonia (less than 0.5 mg per L). Elements also include natural flow regimes that provide flows during the appropriate time of year or, if flows are controlled, minimal flow departure from a natural hydrograph.

(ii) Spawning and rearing habitat. Streams and shoreline springs with gravel and cobble substrate at depths typically less than 4.3 ft (1.3 m) with adequate stream velocity to allow spawning to occur. Areas containing emergent vegetation adjacent to open water, provides habitat for rearing and facilitates growth and survival of suckers, as well as protection from predation and protection from currents and turbulence.

(iii) Food. Areas that contain an abundant forage base, including a broad array of chironomidae, crustacea, and other aquatic macroinvertebrates.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features that are essential to the conservation of the species and which may require special management considerations or protection. Threats identified in the final listing rule for these species include: (1) Poor water quality; (2) potential entrainment at water diversion structures; (3) lack of access to essential spawning habitat; (4) lack of connectivity to historical habitat (i.e., migratory impediments); (5) degradation of spawning, rearing, and adult habitat; and (6) avian predation and predation by or competition with nonnative fish. Poor water quality is particularly associated with high abundance of the blue-green alga Aphanizomenon flos-aque. Core samples of bottom sediments indicate that A. flos-aque was not present in Upper Klamath Lake prior to the 1900s (Bradbury et al. 2004, p. 162; Eilers et al. 2004, p. 14). Its appearance is believed to be associated with increases in productivity of the lake through human influence (NRC 2004, pp. 108-110). This alga now dominates the algal community from June to November, and, because of the high phosphorus concentrations and its ability to fix nitrogen, is able to reach seasonally high biomass levels that eventually produce highly degraded water quality (Boyd et al. 2002, p. 34). As a result of photosynthesis during algal blooms, pH levels increase to stressful levels for fish (Wood et al. 2006, p. 1). Once the algal bloom subsides, decomposition of the massive amounts of biomass can lower dissolved oxygen to levels harmful or fatal to fish (Perkins et al. 2000, pp. 24-25; Wood et al. 2006, p. 1). Additionally, other cyanobacteria (Microcystis sp.) may produce toxins harmful to sucker liver tissue (VanderKooi et al. 2010, p. 2). Special management considerations or protection are therefore needed to protect water quality from the deleterious effects of algal blooms and may include reducing excess phosphorus concentrations by fencing cattle out of riparian areas, reconfiguring agricultural waterways, increasing riparian stands of vegetation, and restoring wetland habitat that is crucial for filtering sediment and nutrients. Hydrographs of both Clear Lake Reservoir and Upper Klamath Lake exhibit patterns of a snow-melt-driven system with highest inflows and levels during spring and early summer, although groundwater also is a significant contributor to Upper Klamath Lake (Gannett et al. 2007, p. 1). However, Clear Lake Reservoir, Gerber Reservoir, and Upper Klamath Lake are managed to store and divert water for irrigation every year. Clear Lake Reservoir is highly sensitive to drought and downstream water delivery because of its small watershed, low precipitation, minimal groundwater input, and high evaporation rates (NRC 2004, p. 129). In the dry years of 1991 and 1992, the level of Clear Lake Reservoir was drawn down to extremely low levels for irrigation supply (Moyle 2002, p. 201). In 1992, Lost River sucker within Clear Lake Reservoir that were examined exhibited signs of stress, including high rates of parasitism and poor body condition (NRC 2004, p. 132). These signs of stress began to decline as the water level in Clear Lake Reservoir rose in 1993, at the end of the drought (NRC 2004, p. 132). In 2009, when lake levels were again low due to drought, diversions from Clear Lake Reservoir were halted in mid-summer, and there were no diversions again in 2010 in order to comply with the biological opinion's requirements for minimum lake elevations to avoid harm to listed fish. Likewise, the amount of available larval habitat and suitable shoreline spring spawning habitat in Upper Klamath Lake is significantly affected by even minor changes in lake elevation (Service 2008, p. 79). Therefore, special management considerations or protection are needed to address fluctuations in water levels due to regulated flow and lake elevation management. Special management may include the following actions: Managing bodies of water such that there is minimal flow departure from a natural hydrograph; maintaining, improving, or reestablishing instream flows to improve the quantity of water available for use; and managing groundwater use. The effects of fluctuations in water levels due to regulated flow management may affect the ability of Lost River sucker and shortnose sucker to access refugia during periods of poor water quality. For example, Pelican Bay appears to act as a key refugium during periods of poor water quality, and efforts to maintain the quality and quantity of the habitat there may be beneficial for suckers (Banish et al. 2009, p. 167). Therefore, special management considerations or protections are needed to address access to refugia and may include the following: Maintaining appropriate lake depths to allow access to refugia; restoring degraded habitats to improve quantity of flow at refugia as well as refugia quality; and maintaining or establishing riparian buffers around refugia to improve refugia water quality. The Klamath Project (Project) stores and later diverts water from Upper Klamath Lake for a variety of Project purposes. These operations result in fluctuating lake levels and flows at the outlet of the lake that differ from historic conditions, some of which increase movement of juvenile fish downstream of Upper Klamath Lake. As such, special management considerations or protection may be needed to address the timing and volume of water that is diverted to maintain sufficient lake elevations. Throughout the Upper Klamath Lake and Lost River Basin, timber harvesting and associated activities (road building) by Federal, State, tribal, and private landowners have resulted in soil erosion on harvested lands and transport of sediment into streams and rivers adjacent to or downstream from those lands (Service 2002, p. 65; NRC 2004, pp. 65-66). Past logging and road-building practices often did not provide for adequate soil stabilization and erosion control. A high density of forest roads remains in the upper Klamath River basin, and many of these are located near streams where they likely contribute sediment (USFS 2010, p. 7). These sediments result in an increase of fine soil particles that can cover spawning substrata. The major agricultural activity in the upper Klamath River basin, livestock grazing, also has likely led to an increase in sediment and nutrient loading rates by accelerating erosion (Moyle 2002, p. 201; Service 2002, pp. 56, 65; McCormick and Campbell 2007, pp. 6-7). Livestock, particularly cattle, have heavily grazed floodplains, wetlands, forests, rangelands, and riparian areas, and this activity has resulted in the degradation of these areas. Poorly managed grazing operations can alter the streamside riparian vegetation and compact soil surfaces, increasing groundwater runoff, lowering streambank stability, and reducing fish cover. The increase in sediment accumulation and nutrient loading is consistent with the changes in land use in the upper Klamath River basin occurring over the last century (Bradbury et al. 2004, pp. 163- 164; Eilers et al. 2004, pp. 14-16). Therefore, special management considerations or protection may be required to improve water quality and include: Reducing sediment and nutrient loading by protecting riparian areas from agricultural and forestry impacts, reducing road density to prevent excess sediment loading, and improving cattle management practices. Lost River sucker and shortnose sucker have limited hydrologic connection to spawning or rearing habitat. For example, lake levels in Clear Lake Reservoir in conjunction with flows in Willow Creek, the sole spawning tributary (Barry et al. 2009, p. 3), may adversely affect sucker populations during the spawning migration. Lake levels may be especially pertinent during years when spring runoff is intermediate and flows are sufficient for spawning migration by the suckers, but are not sufficient enough to increase lake elevations substantially during the narrow spawning window. This situation could create a condition in which flow is adequate for both species to spawn but lake elevation precludes suckers ability to access the habitat, although further research is needed to clarify this dynamic. Likewise, the amount of suitable shoreline spring spawning habitat in Upper Klamath Lake is significantly affected by even minor changes in lake elevation, but it is unknown exactly how such levels directly affect annual productivity. Several shoreline spring-spawning populations, including Harriman Springs and Barkley Springs, have been lost or significantly altered due to railroad construction (Andreasen 1975, pp. 39-40; NRC 2004, p. 228). Historically, wetlands comprised hundreds of thousands of hectares throughout the range of the species (Gearhart et al. 1995, pp. 119-120; Moyle 2002, p. 200; NRC 2004, pp. 72-73), some of which likely functioned as crucial habitat for larvae and juveniles. Other wetlands may have played vital roles in the quality and quantity of water. Loss of ecosystem functions such as these, due to alteration or separation of the habitat, is as detrimental as physical loss of the habitat. Roughly 66-70 percent of the original 20,400 ha (50,400 ac) of wetlands surrounding Upper Klamath Lake was diked, drained, or significantly altered beginning around 1889 (Akins 1970, pp. 73-76; Gearhart et al. 1995, p. 2; Larson and Brush 2010, p. 19). Additionally, of the approximately 13,816 ha (34,140 ac) of wetlands connected to Upper Klamath Lake, relatively little functions as rearing habitat for larvae and juveniles, partly due to lack of connectivity with current spawning areas (NRC 2004, pp. 72-73). Therefore, special management considerations or protection may be needed for water quantity to improve access to spawning locations and quality and quantity of wetlands used as rearing habitat. This may be accomplished by: Improving lake level management to allow access to spawning locations during late winter and early spring, restoring access to wetland rearing habitat, and creating wetland rearing habitat adjacent to lakes and reservoirs. The exotic fish species most likely to affect Lost River sucker and shortnose sucker is the fathead minnow. This species may prey on young Lost River sucker and shortnose sucker and compete with them for food or space (Markle and Dunsmoor 2007, pp. 571-573). For example, fathead minnow were first documented in the upper Klamath River basin in the 1970s and are now the numerically dominant exotic fish in Upper Klamath Lake (Simon and Markle 1997, p. 142; Bottcher and Burdick 2010, p. 40; Burdick and VanderKooi 2010, p. 33). Additional exotic, predatory fishes found in sucker habitats, although typically in relatively low numbers, include yellow perch (Perca flavescens), bullhead (Ameiurus species), largemouth bass (Micropterus salmoides), crappie (Pomoxis species), green sunfish (Lepomis cyanellus), pumpkinseed (Lepomis gibbosus), and Sacramento perch (Archoplites interruptus) (NRC 2004, pp. 188-189). In addition to exotic fish species, recent information has shown that American white pelican (Pelecanus erythrorhynchos) and double-crested cormorant (Phalacrocorax auritus) prey on Lost River sucker and shortnose sucker (Burdick 2012, p. 1). Special management considerations or protection may be needed to protect the forage base from predation by exotic fish species and could be accomplished by the following: Reducing conditions that allow exotic fishes to be successful and restoring conditions that allow Lost River sucker and shortnose sucker to thrive; conducting evaluations to determine methods to remove exotic fish species; determining methods to reduce avian predation; and determining methods to reduce or eliminate competition for the forage base upon which Lost River sucker and shortnose sucker depend to survive.

Life History

Feeding Narrative

Adult: The Lost River sucker is an invertivore that predominantly feeds on zooplankton and macroinvertebrates. The species will also ingest detritus and algae (USFWS 2013b). Both mouth position and gill raker structure suggest that these species are adapted for feeding in a forward manner on prey such as zooplankton, rather than consuming prey from the substrate (USFWS 2013a). Fathead minnows prey on Lost River sucker larvae. Linear regression of length at age indicated that sucker larvae captured on the Sprague River (both wetland and main stem) grew approximately 0.27 mm per day. Lakes and streams that can sustain zooplankton and macroinvertebrates are the key resources required for the species to find adequate food sources. Because larval fish must feed quickly after emerging from gravel, they may move to riparian wetland areas in the upstream portions of the Sprague River during downstream migration to Upper Klamath Lake (Zipper 2014; USFWS 2013b).

Reproduction Narrative

Adult: Spawning occurs in March, April, and May over gravel substrates in rivers and shoreline springs. Females broadcast their eggs, which are fertilized most commonly by two accompanying males, but the number may be as high as seven. The fertilized eggs settle in the top few inches of the substrate until hatching, around 1 week later (USFWS 2013a). Larvae peak in numbers about 3 weeks after peak spawning. Sexual maturity in Upper Klamath Lake occurs between the ages of 6 and 14 years, with most maturing at age 9. The species requires gravel substrates in habitats less than 1.3 m (4 ft.) deep. Each female produces 44,000 to 236,000 eggs per year, with greater than 95 percent of adults spawning every year, based on long-term monitoring conducted by the U.S. Geological Survey (USFWS 2013b; NatureServe 2015). The species is long-lived, with adults living on average approximately 12.5 years (average total life span of approximately 20 to 25 years, including time to reach maturity), and a maximum reported age of 57 (USFWS 2013a; USFWS 2013b). Larger, older females often produce substantially more eggs and, therefore, can contribute relatively more to production than a recently matured female (USFWS 2013a).Known areas of concentrated Lost River sucker spawning in the Williamson and Sprague rivers include the lower Williamson River from river mile 6 to the confluence of the Sprague River (river mile 11); lower Sprague River below the Chiloquin Dam area; and in the Beatty Gap area of the upper Sprague River (river mile 75). Other areas in the Sprague River watershed where Lost River sucker may spawn include the lower Sycan River and the Sprague River near the Nine Mile area. A smaller but significant number of Lost River sucker also spawn over gravel at shoreline springs along the margins of Upper Klamath Lake. Significant spawning aggregations currently occur at Sucker Springs, Cinder Flats, Silver Building Springs, and Ouxy Springs. A smaller number of individuals are also known to spawn at Boulder Springs. Spawning at these springs is very sensitive to lake levels; as levels decline, much of the spawning habitat quickly becomes unavailable (USFWS 2013a).

Geographic or Habitat Restraints or Barriers

Adult: Dam lacking a suitable fishway, high waterfall, and upland habitat (NatureServe 2015).

Spatial Arrangements of the Population

Adult: Uniform

Environmental Specificity

Adult: Narrow/specialist

Tolerance Ranges/Thresholds

Adult: High

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: Requires emergent vegetation for cover.

Habitat Narrative

Adult: Habitat includes deep-water lakes and impoundments, and swift water and deep pools of small to medium rivers. The species occurs in riverine and palustrine habitats, in both marsh and shoreline regions. Suckers can be found throughout the reservoirs they inhabit, but they appear to prefer shorelines with emergent vegetation that can provide cover from predators and invertebrate food. The species is uniformly arranged. Suckers move from lakes into tributary streams to spawn in riffles or runs with gravel or cobble substrate, moderate flows, and depths of 21 to 128 centimeters (8.3 to 50.4 inches) in the benthic zone of river and lake systems. Spawning also occurs along the shore of Upper Klamath Lake (e.g., at spring inflows). Juveniles move downstream into lakes soon after hatching. Mark-recapture data indicate that the two stocks maintain a high degree of fidelity to spawning areas, and seldom interbreed (USFWS 2013b).Larval suckers prefer shallow, nearshore, and emergent vegetated habitat in both the lakes and rivers. Lake suckers such as Lost River sucker are relatively tolerant of water quality conditions unfavorable for many other fishes, tolerating higher pH (more basic conditions), temperatures, and unionized ammonia concentrations; and lower dissolved oxygen concentrations (USFWS 2013b).Wetlands are likely to play a major role in survival and growth of larval suckers in the upstream reaches of the Sprague River. Dams lacking a suitable fishway, high waterfalls, and upland habitats can act as barriers for the species (NatureServe 2015; Zipper 2014).

Dispersal/Migration

Motility/Mobility

Adult: High

Migratory vs Non-migratory vs Seasonal Movements

Adult: Seasonal movements/migrations to spawning habitats.

Dispersal

Adult: Migrates up tributary streams in spring to spawn; spawning migrations in the Sprague River begin in March and April (NatureServe 2015).

Immigration/Emigration

Adult: Does not immigrate or emigrate.

Dispersal/Migration Narrative

Adult: Lost River suckers will migrate seasonally and are highly mobile. Individuals migrate up tributary streams in spring to spawn, typically during hours of darkness; spawning migrations in the Sprague River begin in March and April. Open, deep lake and stream systems and systems with fishways are required for dispersal (NatureServe 2015; Zipper 2014). Out-migrating larvae (those larvae that have hatched and begun to drift downstream), as well as spawn-ready adults, use river and stream habitat as a migration corridor, but specific habitat requirements during these migrations are unknown. The outlet river of Upper Klamath Lake, the Link River, flows a short distance before entering Lake Ewauna. This habitat functions primarily as a corridor for large numbers of larval and juvenile suckers entrained in the downstream flow moving through the Link River Dam. The river may also potentially permit movement of adults upstream toward spawning habitats during spring (USFWS 2013b; USFWS 2013a).

Additional Life History Information

Adult: Suckers migrate during hours of darkness (Zipper 2014).

Population Information and Trends

Population Trends:

Upper Klamath Lake: In 2007, a decline of 56 to 75 percent relative to 2002 abundance. Clear Lake Reservoir: relatively stable with somewhat diverse age structures (1989 through 2000) (USFWS 2013a). Based on the future scenarios we analyzed here, it is likely that the Lost River sucker will continue to decline precipitously if conditions in Upper Klamath Lake remain unchanged. The species may remain in 50 years, but it is likely that it will be critically few in numbers. Given that the only other spawning population of this species, Clear Lake Reservoir, is extremely small, a substantial reduction in Upper Klamath Lake will put the species perilously close to extinction. These conclusions rely on the assumption that survival rates continue in the future similar to the recent past; however, if survival should decrease due to ageing populations, then we expect the declines to accelerate. This could significantly truncate our frame of reference. If current conditions continue, we also expect the shortnose sucker population in Upper Klamath Lake to become extirpated within the next 30-40 years. Projections suggest that this population will decline 78% over the next 10 years to a level below 5,000 individuals. This would result in only two populations remaining for the species, both of which are highly genetically introgressed with the Klamath largescale sucker and geographically isolated behind dams without fish passage. Both species are likely to realize reduced risk of extinction from implementation of the rearing program, but landscape-scale improvements to nutrient loads in Upper Klamath Lake will be necessary to achieve full recovery. The dire conditions of Lost River sucker in Clear Lake Reservoir suggest that recovery of the species will likely be unattainable without additional recovery efforts in this waterbody. Recovery of the species is likely to require substantially more drastic actions than the few considered here. Recovery of shortnose sucker appears more achievable in the Lost River sub-basin under the scenarios assessed, but uncertainties about the overall impacts of genetic introgression remain (USFWS, 2019).

Species Trends:

The long-term trend is a decline of greater than 50 percent. In the short term, the population is relatively stable (NatureServe 2015).

Resiliency:

Overall resiliency for Lost River sucker is generally low, primarily because redundancy is critically low. There are only three distinct spawning populations: Upper Klamath Lake-springs, Upper Klamath Lakeriver, and Clear Lake Reservoir. Two of the remaining populations (Clear Lake Reservoir and Upper Klamath Lake-springs) have very low numbers and are at a high risk of localized catastrophic events. The Clear Lake Reservoir population is completely separate from the others. As a species, Lost River sucker appear to be relatively genetically distinct from the other sucker species in the basin (USFWS, 2019).

Representation:

Representation of diversity within and among populations of each species is difficult to quantify. Hybridization and introgression between shortnose sucker and Klamath largescale sucker is well documented, and evidenced by phenotypic intermediates in morphology (Markle et al. 2005 p. 476) and lack of discrimination among molecular markers (Dowling et al. 2016 p. 19). However, morphological distinctiveness of the species varies by location (Markle et al. 2005 p. 476). Spawning between these species is partially isolated temporally and spatially (Markle et al. 2005 p. 480). In Upper Klamath Lake morphological attributes of both species are more or less maintained, while other populations such as Gerber and Clear Lake reservoir show a spectrum of morphological intermediates (Dowling 2005 pp. 21 & 22). Despite genetic evidence of hybridization, the access to a diversity of habitats presumably maintains phenotypes of both species to some degree. Genetic representation is lower for both species in Clear Lake Reservoir as compared to conspecifics in Upper Klamath Lake. In this reservoir, both species have lower heterozygosity and allelic richness compared to conspecifics in Upper Klamath Lake (Smith and VonBargen 2015 p. 24). Lower genetic diversity could be due to the population being derived from a limited number of individuals trapped when the dam was installed (i.e., founder effects) or simply due to genetic drift associated with small population size. Additionally, lack of connectivity with other populations also further depresses genetic diversity via reduced gene flow. Of more importance, the shortnose sucker population in Clear Lake Reservoir is highly introgressed with Klamath largescale sucker (Tranah and May 2006 p. 313, Dowling et al. 2016, entire). Shortnose sucker are more genetically similar to Klamath largescale within the same subbasin than they are to conspecifics from the other subbasin (Smith and VonBargen 2015 p. 14). Within the Lost River subbasin, shortnose sucker and Klamath largescale sucker can be difficult to distinguish morphologically. This can potentially erode species distinctiveness (genetic representation) within the population as well as reduce the abundance of phenotypic shortnose sucker (i.e., abundance of individuals that possess the morphology associated with shortnose sucker and thereby reduce the overall resiliency of the species within the reservoir). Genetic representation within the Gerber Reservoir population is very similar to that of Clear Lake Reservoir. The shortnose sucker are highly introgressed with Klamath largescale, and the population is isolated from other populations. Unlike the shortnose sucker, hybridization and introgression involving the endangered Lost River sucker does not appear to be extensive (Dowling et al. 2016 p. 18). At present, both endangered suckers in Upper Klamath Lake possess population sizes large enough to maintain genetic diversity and prevent the negative effects of inbreeding. We cannot make similar conclusions about other populations because we lack accurate estimates of population sizes. The draining of Tule Lake and Lower Klamath Lake and the construction of dams and irrigation structures has isolated the populations such that there is no exchange of individuals between the major remaining populations in Upper Klamath Lake, Gerber Reservoir, and Clear Lake, and the system no longer functions as a metapopulation. This reduction of redundancy and connectivity could also have negative impacts on representation of diversity within the species. Maintenance of ecological and phenotypic distinction between shortnose sucker and Klamath largescale in Upper Klamath Lake suggest that introgression between these species does not threaten the resiliency of the endangered shortnose sucker population in Upper Klamath Lake. However, the resiliency of the shortnose sucker populations in Clear Lake Reservoir and Gerber Reservoir may be even less than it appears because few individuals possessing the distinct genetics and ecology of the species occur (USFWS, 2019).

Redundancy:

Redundancy of populations for these species has always been relatively low. Pre-settlement populations probably numbered no more than four for each species. Redundancy for both species has been greatly reduced due to the destruction of at least two major populations (Lower Klamath Lake and Tule Lake) as well as numerous subpopulations or spawning locations, namely at springs throughout Upper Klamath Lake and the Lost River. The draining of Tule Lake and Lower Klamath Lake for agricultural use essentially eliminated two of the major water bodies inhabited by both species. Lower Klamath Lake populations are completely extirpated and Tule Lake has a very small number of individuals that lack access to suitable spawning habitat. Because of this, Tule Lake does not provide substantial redundancy for the species. These water bodies represented two of the three major lake/marsh complexes in the Upper Klamath Basin; the remaining one is Upper Klamath Lake, which supports the largest extant populations of both species. Although large swaths of habitat were destroyed throughout the range of the species, some of the developments for agricultural use increased available habitat for Lost River and shortnose suckers. In particular, Clear Lake was enlarged and lake elevations were stabilized by the creation of Clear Lake Reservoir. This increased the amount of accessible habitat available for this population, but it is unclear how this may have also affected the quality of habitat – for better or for worse. Clear Lake Reservoir supports populations of both Lost River and shortnose sucker at present. Additionally, the construction of a dam on Miller Creek to create Gerber Reservoir in the Lost River drainage created new lacustrine habitat in the reservoir that currently supports a population of shortnose sucker. Reservoirs constructed for hydropower production along the main stem of the Klamath River also support small numbers of suckers, but there is no evidence that these populations reproduce. Removal of these Klamath River dams under consideration so it is very unlikely that these populations will provide redundancy for the species in the future. Suckers were historically able to move among the various lake habitats, at least during periods of high water. There are important differences in the status and threats to the remaining populations, so the details for each location are discussed separately. In terms of redundancy within a population, only the Lost River sucker in Upper Klamath Lake currently have more than one substantial spawning subpopulations. This provides some redundancy, albeit small, because of the low number of spring-spawners and the temporal and spatial overlap of spawners and adult habitat. For example, climate change will likely reduce snow pack and therefore reduce spring runoff in the river because of warmer temperatures and more precipitation falling as rain (Markstrom et al. 2012, entire, Risley et al. 2012, entire). These changes may reduce spawning success in the Williamson and Sprague Rivers, but are unlikely to impact the groundwater seeps in the same way. There are four primary spawning areas along the eastern shoreline (Sucker, Silver Building, Ouxy, and Cinder springs), which are all within 6 km (3.7 mi) of each other. This proximity makes these spawning sites of reduced utility in resisting catastrophic disturbances. In addition to these extant spawning locations, there were additional historical spawning subpopulations at Barkley Springs, Harriman Springs and likely other springs throughout Upper Klamath Lake. These subpopulations have disappeared completely, greatly reducing the redundancy within the population. This loss increases the sensitivity of the population to widespread or catastrophic disturbances. Both species in Clear Lake are entirely dependent on the Willow Creek watershed for spawning habitat. Lost River sucker utilize the lower portions of the creek as far as the confluence with Boles Creek, as well as Boles Creek (a tributary to Willow Creek) as far as Avanzino Reservoir (approximately 43 km [27 mi]). Shortnose sucker ascend both Willow Creek and Boles Creek much further than LRS (approximately 143 km [89 mi]). This provides a small amount of resilience for the SNS population in Clear Lake Reservoir, but the linkage between the two streams suggests that the redundancy benefit provided is minimal. It is not clear why LRS do not utilize the higher reaches of Willow Creek, especially because LRS are the species that travel the greater distance in the Sprague River. There are at least two distinct spawning tributaries for shortnose sucker in the Gerber Reservoir system: Barnes Valley Creek and Ben Hall Creek. Approximately 88 percent of the adults leaving Gerber Reservoir to spawn ascend Barnes Valley Creek. The presence of two spawning streams creates some redundancy within the population that may help to increase the probability of successful spawning each year, as well as reduce the risk of localized catastrophic events, but the unbalanced utilization of the sites may reduce that benefit somewhat. Listed Klamath suckers also occur in small numbers in a handful of other waterbodies. These populations consist almost exclusively of shortnose sucker, but also include a handful of Lost River sucker. The shortnose sucker are found in Lake Ewauna, Tule Lake, the main stem reservoirs, and the Lost River proper (Shively et al. 2000 pp. 82–86). Lake Ewauna probably functions as a subpopulation to Upper Klamath Lake to some degree. Hundreds of listed suckers (both species) have been captured, tagged, and translocated to Upper Klamath Lake from Lake Ewauna since 2010 (Kyger and Wilkens 2011 p. 3; N. Banet, U.S. Geological Survey, personal comment). Similarly, hundreds of individuals of both species were captured in Tule Lake during a three-year effort (Hodge and Buettner 2009 pp. 4–6). A two-year effort in the main stem reservoirs on the Klamath River (Desjardins and Markle 2000 pp. 14 & 15) produced slightly more than 200 captures, 99 percent of which were shortnose sucker. The number of catches given the effort suggests that these populations possess very few individuals. Lost River sucker only occur in Tule Lake in addition to the populations discussed above (Shively et al. 2000 pp. 87–89). All of these minor populations possess extremely low resiliency due to a combination of degraded habitat, low numbers, and restricted access to suitable spawning habitat (USFWS, 2019).

Population Growth Rate:

Stable

Number of Populations:

Two; this species is represented by only two populations that are sustaining themselves without the input of larvae or older suckers from other areas: Upper Klamath Lake and Clear Lake Reservoir (USFWS 2013b).

Population Size:

2,500 to 100,000 individuals (NatureServe 2015). Upper Klamath Lake: estimates of 50,000 to 100,000 individuals in 2011. Spawning in Willow Creek up from Clear Lake Reservoir: slightly fewer than 500 individuals captured in 2011. Tule Lake: 400 individuals captured between 2006 and 2008. Keno Reservoir: 200 individuals between 2008 and 2011 (USFWS 2013b).

Adaptability:

Low

Additional Population-level Information:

Historically, Lost River suckers were abundant enough to provide an important food resource for indigenous people and later settlers and their livestock (hogs). Now the species is extirpated in Lower Klamath Lake and Sheepy Lake, uncommon in Upper Klamath Lake and Tule Lake, and common only in Clear Lake Reservoir (NatureServe 2015).Because of the generally dispersed distribution of Lost River sucker and extensive habitat, accurate estimates of population size are extremely difficult to obtain. Additionally, most populations have not been monitored sufficiently to produce adequate data to even attempt a reasonable estimate of population size. Recent size distribution trends reveal that spawning populations comprise mostly similarly aged, older individuals (USFWS 2013b; USFWS 2013a).

Population Narrative:

There are currently only two self-sustaining populations of Lost River sucker: Upper Klamath Lake and Clear Lake Reservoir. Historically, Lost River suckers were abundant enough to provide an important food resource for indigenous people and later settlers and their livestock (hogs). Now the species is extirpated in Lower Klamath Lake and Sheepy Lake, uncommon in Keno Reservoir and Tule Lake, and common only in Upper Klamath Lake and Clear Lake Reservoir. Recent size distribution trends reveal that spawning populations comprised mostly similarly aged, older individuals (NatureServe 2015; USFWS 2013b). In the Upper Klamath Lake, the Lost River sucker spring-spawning abundance in 2007 was estimated to be 56 percent and 75 percent of 2002 abundances for males and females, respectively; although the exact abundances are unknown, and these values represent estimates of realized population change. In the Clear Lake Reservoir, early data from the mid-1970s suggested that populations were in decline; however, monitoring from 1989 through 2000 indicated that populations are relatively stable, with somewhat diverse age structures (USFWS 2013a).Because of the generally dispersed distribution of Lost River sucker and its extensive habitat, accurate estimates of population size are extremely difficult to obtain. Additionally, most populations have not been monitored sufficiently to produce adequate data to even attempt a reasonable estimate of population size. In 2011, Upper Klamath Lake monitoring detected or captured approximately 25,000 tagged Lost River suckers participating in the annual spawning congregations and runs. Estimates of what proportion of the total population is tagged are unavailable, but these data suggest that Lost River suckers number between 50,000 and 100,000 in Upper Klamath Lake. Although mark-recapture monitoring has occurred on the Clear Lake Reservoir population for several years, capture rates of Lost River suckers overall are low. Slightly fewer than 500 tagged Lost River suckers were detected during the 2011 spawning run up Willow Creek from Clear Lake Reservoir. At the time of listing, the Lost River sucker was believed to have been extirpated from Tule Lake. However, during a 3-year monitoring effort (2006 through 2008), approximately 400 individual Lost River suckers were captured here. A similar effort to assess the population in Keno Reservoir (2008 through 2011) detected approximately 200 individual Lost River suckers (USFWS 2013a).

Threats and Stressors

Stressor: Adverse water quality
Exposure: Conditions that are potentially harmful or fatal to the species, large amounts of dissolved nutrients, and algal blooms.
Response: Mortality events caused by poor water quality.
Consequence: Reduction in population, extirpation, and habitat loss and degradation.
Narrative: Lake suckers such as Lost River sucker are relatively tolerant of water quality conditions unfavorable for many other fishes, tolerating higher pH (more basic conditions), temperatures, and unionized ammonia concentrations; and lower dissolved oxygen concentrations. Nevertheless, many of the water bodies currently occupied by Lost River sucker periodically possess conditions that are potentially harmful or fatal to the species. Much of this is due to large amounts of dissolved nutrients that promote biological productivity, such as algal growth. Throughout the year, the dynamics of algal blooms affect dissolved oxygen levels (ranging between anoxic to supersaturated conditions), pH, and unionized ammonia, all of which can impact fish health and survival. These processes are particularly important in Upper Klamath Lake and Keno Reservoir. Adverse water quality is a critical threat to Lost River sucker, and substantial improvement is not expected in the near future. It is reasonable to expect that mortality events caused by poor water quality that will significantly affect sucker populations will continue to periodically occur in Upper Klamath Lake. Given the reduced numbers of individuals and populations of this species, these poor water quality events may represent a significant threat to the species (USFWS 2013b).

Stressor: Habitat degradation
Exposure: See narrative.

Response: See narrative.
Consequence: See narrative.
Narrative: Approximately 400 habitat restoration projects have been recently completed or are being planned in the Upper Klamath Lake basin. Because such efforts are relatively recent, population-level responses by Lost River sucker are not yet apparent. The foremost project is the restoration of the delta where the Williamson River enters Upper Klamath Lake. Lost River sucker have been documented using portions of the approximately 6,000 ac. of potential larvae and juvenile rearing habitat that were restored in 2007 and 2008. Although more time will be needed for the area to recover to its previous natural state due to the subsidence from agricultural use, this is still a major advancement toward the recovery of Lost River sucker. Another significant recovery action that occurred was the removal of Chiloquin Dam on the Sprague River in 2008. The dam was identified in the 1988 listing as a threat to the Lost River sucker because it blocked access to upstream spawning areas. Removal effectively unblocks approximately 120 km (75 mi.) of the Sprague River for spawning and migration of adults and larvae. Insufficient time has passed to completely assess the overall effects on the population, but it is believed that this extremely important action, in conjunction with the many other restoration activities, will result in improved status of the species (USFWS 2013b).

Stressor: Nonnative fish
Exposure: Fathead minnows.
Response: Larvae are eaten by adult fathead minnows.
Consequence: Population decline.
Narrative: In Upper Klamath Lake, higher fathead minnow abundance was negatively associated with Lost River sucker survival rates. These data suggest that predation by highly abundant fathead minnows may be an important threat to larval sucker survival, which may be exacerbated by the loss of emergent wetland habitat that provides cover for the Lost River sucker larvae. Other nonnative fishes may also pose a threat to Lost River sucker; however, little quantitative information exists to indicate their influence on sucker abundance and distribution (USFWS 2013b).

Stressor: Predators
Exposure: Birds
Response: Birds prey on Lost River sucker.
Consequence: Unknown
Narrative: Although not mentioned at the time of listing as a threat, several species of birds prey on Lost River sucker and shortnose sucker, but the ultimate effect to the status of the species from these avian predators is currently unknown. Bald eagles have been observed perching in trees directly above Ouxy Springs, which is one of five areas where Lost River sucker spawn along the eastern shoreline of Upper Klamath Lake. In Clear Lake Reservoir, radiotags and Passive Integrated Transponder tags of individuals of both species have been located on islands associated with nesting colonies of American white pelican (Pelecanus erythrorhynchus), double-crested cormorant (Phalacrocorax auritus), and great blue heron (Ardea herodias). Predation on spawning adults increases mortality rates of this crucial life stage, and may alter behavior during this critical period. For example, predation on adults at spawning sites may limit the amount of time spent on the spawning ground. Throughout the range of the species there are numerous species of piscivorous birds, including terns, grebes, and mergansers, that may prey on juvenile and larvae suckers (USFWS 2013b).

Stressor: Blue green algal toxins
Exposure: Microcystin, an algal toxin.
Response: Toxin is indirectly ingested when suckers consume midge larvae.
Consequence: Unknown
Narrative: Of recent interest are the effects of microcystin, an algal toxin that affects the liver. In a 2007 survey, 49 percent of a sample of juvenile suckers (n = 47) collected at 11 shoreline sites exhibited indications of microcystin exposure. However, these data are preliminary and further investigations are required. For example, the means by which the toxin is introduced into the body remains unknown. One hypothesis is that the toxin is indirectly ingested when suckers consume midge larvae (Chironomidae), which feed on the algae (USFWS 2013b).

Stressor: Regulatory mechanisms
Exposure: Inadequacy of existing regulatory mechanisms.
Response: Loss of habitat or habitat degradation from populations, and potential populations not being properly identified and maintained.
Consequence: Reduction in population, extirpation, habitat loss, and degradation.
Narrative: The Endangered Species Act (ESA) is the primary federal law that provides protection for this species since its listing as endangered in 1988. Other federal and state regulatory mechanisms provide protections for the species based on current management direction, but do not guarantee protection for the species absent its status under ESA, with the exception of ESAs for each state. In general, these regulatory mechanisms provide protections to the species by restricting take (state ESAs), by requiring review of actions that may impact the species (California Environmental Quality Act and National Environmental Policy Act), and by providing broad-scale improvements to habitat (Clean Water Act) or other means that affect habitat (such as water regulations). Nevertheless, other laws and regulations have limited ability to protect the species in the absence of the ESA (USFWS 2013b).

Stressor: Entrainment
Exposure: Water management structures and unscreened diversions.
Response: Fish perish after becoming trapped.
Consequence: Population decline.
Narrative: Movement of fish into irrigation systems through unscreened diversions was identified as a threat to the suckers at the time of listing. Since listing, private landowners, the Oregon Department of Fish and Wildlife, the Bureau of Reclamation, the Natural Resource Conservation Service, the U.S. Fish and Wildlife Service, and others have built or funded construction of many new fish screens in the upper basin. As a result, the threat of entrainment (loss of fish as result of being drawn into water management structures) is now lower than at the time of listing. Recently installed fish screens in the upper basin include the A-Canal (2003), Agency Lake Ranch (2002), Clear Lake Reservoir (2003), Miller Island (2003), Wood River Ranch (2004), and Geary Canal (2009). Various state and federal screening and passage programs, coordinated in the upper basin through a working group led by the Bureau of Reclamation, are addressing the need for additional screening and passage for suckers. The Bureau of Reclamation surveyed water diversion structures throughout the Klamath Project service area (which excluded nonproject users) between 1997 and 2000. This survey documented approximately 200 diversions that were directly connected to Lost River sucker habitat. A few of these are very large and likely impact the species, but many are small and have minimal impacts. We do not believe that most of the small diversions pose a serious threat to Lost River sucker populations because these smaller diversions typically draw water from the streams and rivers, but most suckers are

in the lakes when the diversions are in operation. Also, small diversions draw relatively moderate currents that are likely to only entrain larvae, which are produced in large numbers, naturally experience very high rates of mortality, and would not be benefitted by most screens, which typically only effectively exclude fish that are larger than 30 mm (1 inch) in length (USFWS 2013b).

Stressor: Climate change
Exposure: Global and regional changes in climate.
Response: Loss of individuals and continued reduction in population.
Consequence: Reduction and/or loss of habitat, reduction in population, and population extirpation.
Narrative: Climate variability, such as fluctuations between wet and dry periods, is part of natural processes; however, climatic models suggest that many of the recent trends in climate are driven by anthropogenic causes. Since the 1950s, western North America generally has exhibited trends toward less snowfall, earlier snowmelt, and earlier peak spring runoff, much of which cannot be attributed to natural fluctuations. Furthermore, models indicate that these trends are likely to continue in the future. More specifically, a suite of climate models predict that over the next 100 years the mean flow of the Sprague River will increase during winter months but decrease during the spawning period, a pattern which is likely to be exhibited throughout the upper Klamath Basin. It is difficult to accurately predict how such climatic changes will affect the Lost River sucker. These species are adapted to periodic droughts; but, given the current reduced state of the species, they may be negatively impacted if there is an increase in the intensity or frequency of droughts, or if there is a substantial shift in the timing of snowmelt and runoff. Likewise, detrimental changes in refugia availability or community composition may also accompany climate change (USFWS 2013b).

Recovery

Reclassification Criteria:
Current spawning and rearing habitat is maintained and improved access ensures annual use (USFWS 2013a; USFWS 2013b).

A range-wide Spawning and Rearing Enhancement Plan has been developed and implemented. This plan shall identify and prioritize areas of potential spawning and rearing habitat for enhancement and/or restoration, including areas that are degraded or unavailable due to lack of connectivity or passage (USFWS 2013a; USFWS 2013b).

Connectivity and access is ensured to habitats that provide refuge to suckers to avoid poor water quality (particularly Pelican Bay) during the months of July, August, and September—Upper Klamath Lake Recovery Unit (USFWS 2013a; USFWS 2013b).

Natural vegetated wetland areas are restored, including in-stream, wetland, and riparian areas around the mouth of Willow Creek where it meets Clear Lake Reservoir and throughout its drainage—Clear Lake Reservoir Management Unit (USFWS 2013a; USFWS 2013b).

Newly identified or clarified effects of predation and disease are minimized through implementation of recommendations from ongoing scientific research that clarifies the interaction of Lost River sucker with predators and pathogens (USFWS 2013a; USFWS 2013b).

An Entrainment Reduction Plan has been developed and implemented. This plan shall identify and prioritize screening of diversions throughout upper Klamath Basin, including the Klamath Project, and propose strategies for efficient reduction of entrainment (USFWS 2013a; USFWS 2013b).

Establishment of two additional recurring and successful spring-spawning populations in the Upper Klamath Lake-Spring Management Unit (USFWS 2013a; USFWS 2013b).

Development and implementation of a plan to assess, monitor, and improve juvenile and sub-adult vital rates and demography, including threats and negative impact reduction. This plan shall also designate specific demographic or vital rate targets, and strategies for achieving these targets, important for downlisting and delisting (USFWS 2013a; USFWS 2013b).

The effects of detrimental water quality have been minimized through implementation of recommendations from ongoing scientific research that clarifies the relationship of these factors with sucker mortality—Upper Klamath Lake Recovery Unit (USFWS 2013a; USFWS 2013b).

Delisting Criteria:
In addition to the reclassification criteria, the following additional criteria must be met:

The states of Oregon and California and the Klamath Tribes, collaboratively or separately, should prepare and finalize population management plan(s) for the Lost River sucker (USFWS 2013a; USFWS 2013b).

After 25 years, the average annual rate of population change is greater than one, and the number of spawning individuals is greater than what was present in the baseline years for the Upper Klamath Lake River and Upper Klamath Lake Spring Management Units. Twenty-five years equates to approximately two average adult life spans for Lost River sucker, and will enable assessment of the populations' response to cyclical threats, such as periodic die-offs and drought. 2002 will serve as the baseline year for Lost River sucker, because this is the first year in which estimates of this type are statistically valid (USFWS 2013a; USFWS 2013b).

Recovery Actions:
- Restore or enhance spawning and nursery habitat in the Upper Klamath Lake and Lost River Recovery Units (USFWS 2013a).
- Reduce negative impacts of poor water quality where necessary (USFWS 2013a).
- Clarify and reduce the effects of introduced species on all life stages by conducting and applying scientific investigations (USFWS 2013a).
- Reduce the loss of individuals to entrainment (USFWS 2013a).
- Establish a redundancy and resiliency enhancement program (USFWS 2013a).
- Increase juvenile survival and recruitment to spawning populations (USFWS 2013a).
- Maintain and increase the number of recurring, successful spawning populations (USFWS 2013a).
- Establish a Klamath Basin Sucker Recovery Implementation Program (USFWS 2013a).
- Establishment of a Recovery Implementation Team. The revised recovery plan for the Lost River sucker (USFWS 2013a) identifies several actions that will promote recovery of this

species. Among these is the establishment of a Recovery Implementation Team to coordinate and assess implementation of the plan. This is a very important step to ensure success of the plan (USFWS 2013b).

- Improving Recruitment. The most critical need for this species is to restore natural rates of recruitment to Upper Klamath Lake and Clear Lake Reservoir populations. Research is needed to clarify how adverse water quality (including algal toxins), entrainment, and habitat availability affect this lack of recruitment (USFWS 2013b).
- Auxiliary Populations. Given that Lost River sucker are steadily declining in the only two populations with any appreciable reproduction, the Revised Recovery Plan (USFWS 2013a) calls for the establishment of auxiliary populations within the natural range of the species to guard against short-term extinction risks. This includes the reestablishment of spawning populations in the Upper Klamath Lake tributaries and springs. The Revised Recovery Plan (USFWS 2013a) also stresses the importance of conserving the Tule Lake population for redundancy in the Lost River system. The plan also identifies several priority actions, which include investigating the potential of restoring spawning habitat for this population (USFWS 2013b).
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Conservation Measures and Best Management Practices:

- Klamath Basin Sucker Assisted Rearing Program One way to improve recruitment in the face of complete early life mortality is through an assisted rearing program. As discussed in Chapter 3, an assisted rearing program was initiated in 2015 with the dual goals of offsetting the harm and harassment of age 0 suckers during the operation of the Bureau of Reclamation's Klamath Irrigation Project and improving the status of SNS in Upper Klamath Lake population through successful recruitment. At present, this effort targets the release of 3,500 subadults (i.e., juveniles between 1 – 4 years old) per year that were collected as larvae from the Williamson River. The first release, which is likely to be substantially smaller than the target, occurred in spring 2018. The current program rears larvae of both endangered SNS and LRS, as identification during early life-stages is problematic. As identification methods become available, efforts will increasingly target SNS. The scale of the Klamath Basin Sucker Assisted Rearing Program is likely to be adjusted in the future to meet recovery goals for both species. Therefore, we present projections for Upper Klamath Lake sucker populations with the addition of varying numbers of individuals for varying durations. The full details of the modeling and the statistical methods are detailed elsewhere (Rasmussen and Childress 2018, entire); however, two assumptions are important for interpretation of the results presented here. First, annual survival in the future was assumed to remain similar to what was been observed in the years 2002-2015. Second, stocked individuals were assumed to enter the population at age 4 and survive at the same rates as adults. This second assumption was necessary because no information on early life survival or the survival of reared individuals in Upper Klamath Lake was available. However, this assumption means that actual production of stocked individuals would need to be higher than the nominal rates presented here to achieve the same results. Higher production would be necessary to offset mortality prior to reaching age 4. (USFWS, 2020)
- RECOMMENDATIONS FOR FUTURE ACTIONS Expand and Improve the Rearing Program The rearing program provides the best short-term avenue to increase the number of Lost River sucker in Upper Klamath Lake. This effort was identified as a priority Recovery Action (Action # 5) in the revised Recovery Plan (USFWS 2013a). Actions should focus on improving the survival and growth of individuals while in captivity, maximizing survival and recruitment once reintroduced into Upper Klamath Lake, and increasing the overall numbers of individuals stocked. Phosphorus Reduction Poor water quality conditions in Upper Klamath Lake appear to be the most likely driver of

persistent recruitment failures in the system. The principal driving factor of the water quality dynamics is the influx of phosphorus into the lake. Specific plans should be developed and actions implemented to secure long-term reduction of phosphorus levels in the system (Recovery Action #2). Adaptive Management The most critical need for this species is to restore natural rates of recruitment to all populations. However, the complexity of biological and physical systems makes it very difficult to determine how to achieve this goal. Adaptive management should be used to implement recovery efforts (including the priorities named above) to ensure the most effective progress towards recovery (Recovery Action #8). Adaptive management includes a cycle of deciding on priority actions, action design, implementation, appropriate monitoring, evaluation, and adjustment of priorities and designs as necessary (USFWS, 2019a)

Additional Threshold Information:

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SPECIES ACCOUNT: *Dionda diaboli* (Devils River minnow)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/20/1999; southeast Region (R2) (USFWS, 2016)

Physical Description

Adult Devils River minnows reach sizes of 25-53 mm (1.0-2.1 in.) standard length. The fish has a wedge-shaped caudal spot (near the tail) and a pronounced lateral stripe extending through the eye to the snout but without reaching the lower lip. The lateral-line pores are marked above and below by small black spots of melanin, forming two parallel rows of “dashes.” The species has a narrow head and prominent dark markings on the scale pockets of the body above the lateral line, producing a crosshatched appearance when viewed from above (Hubbs and Brown 1956) (USFWS, 2005).

Taxonomy

A member of the minnow family (Cyprinidae) (USFWS, 2016). The Devils River minnow is part of a unique fish fauna, which includes Mexican peripherals, local endemics, and widespread North American fishes (Hubbs 1957; Miller 1978; Garrett 1997; Edwards et al. 2004) (USFWS, 2005).

Historical Range

Its historic range includes Rio Grande tributary streams in Val Verde and Kinney counties, Texas, (Devils River, San Felipe, Sycamore, Pinto, and Las Moras creeks) and several streams in northern Mexico. The fish has been eliminated or reduced throughout much of its range (USFWS, 2016).

Current Range

Currently, it occurs in only three streams in Val Verde and Kinney counties: Devils River, San Felipe Creek, and Pinto Creek (USFWS, 2008).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/12/2008.

Legal Description

On August 12, 2008, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Dionda diaboli (Devils River minnow) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes five critical habitat units (CHUs), in Texas (73 FR 46988-47026).

The critical habitat designation for Dionda diaboli includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Dionda diaboli.

Critical Habitat Designation

The critical habitat designation for Dionda diaboli includes five CHUs, which encompass approximately 16.5 stream miles in Val Verde and Kinney Counties, Texas (73 FR 46988-47026).

Unit 1—Devils River Unit - Unit 1 consists of approximately 43.6 stream km (27.1 stream mi) of the Devils River; 1.1 stream km (0.7 stream mi) of Phillips Creek; and 2.3 stream km (1.4 stream mi) of Dolan Creek. Phillips Creek and Dolan Creek are small tributaries to the Devils River that contain the PCEs and are occupied by the Devils River minnow. The upstream boundary on the Devils River is at, and includes, Pecan Springs. The downstream boundary on the Devils River is 3.6 stream km (2.2 stream mi) below Dolan Falls. Phillips Creek is included in this unit from the confluence with the Devils River to a point 1.1 stream km (0.7 stream mi) upstream. Dolan Creek is included from the confluence with the Devils River 2.3 stream km (1.4 stream mi) upstream to Dolan Springs. Including all three streams, the total distance in the Devils River Unit is approximately 47.0 stream km (29.2 stream mi).

Unit 2—San Felipe Creek Unit - Unit 2 consists of approximately 7.9 stream km (4.9 stream mi) on San Felipe Creek, 0.8 stream km (0.5 stream mi) of the outflow of San Felipe Springs West, and 0.3 stream km (0.2 stream mi) of the outflow of San Felipe Springs East. The upstream boundary on San Felipe Creek is the Head Springs located about 1.1 stream km (0.7 stream mi) upstream of the Jap Lowe Bridge crossing. The downstream boundary on San Felipe Creek is in the City of Del Rio 0.8 stream km (0.5 stream mi) downstream of the Academy Street Bridge crossing. The unit includes the outflow channels of San Felipe Springs West and San Felipe Springs East. These channels are included in the critical habitat unit from their spring origin downstream to the confluence with San Felipe Creek. Including all three streams, the total distance included in the critical habitat in the San Felipe Creek Unit is approximately 9.0 stream km (5.6 stream mi). For specific coordinates of the boundaries for the critical habitat designation, please reference to the unit descriptions in the Regulation Promulgation section below.

Unit 3—Pinto Creek Unit - Unit 3 consists of approximately 17.5 stream km (10.9 stream mi) on Pinto Creek. The upstream boundary is Pinto Springs. The downstream boundary is 100 m (330 ft) upstream of the Highway 90 Bridge crossing of Pinto Creek.

Unit 4—Sycamore Creek Unit - The documented habitat for Devils River minnow in Sycamore Creek is at the U.S. Highway 277 bridge (Garrett et al. 1992, p. 265). Based on this information, we have estimated a critical habitat area of 4 stream km (about 2.5 stream mi) encompassing this site. Garrett et al. (1992, p. 265–266) recognized that the majority of surface flow in the drainage comes from Mud Creek, an eastern tributary that confluences with Sycamore Creek approximately 3 stream km (about 2 stream mi) upstream of the U.S. Highway 277 bridge crossing. The origin of the surface flows in Mud Creek is Mud Springs, located about 24 air km (about 15 air mi) north of U.S. Highway 277 crossing of Sycamore Creek and north of the U.S. Highway 90 (Brune 1981, p. 276). Despite collection efforts from Mud Creek, Devils River minnow has not been documented to occur there (Garrett et al. 1992, p. 266).

Unit 5—Las Moras Creek Unit - The only confirmed habitat for Devils River minnow in Las Moras Creek is at the headwater spring on the grounds of Fort Clark in Brackettville based on collections in the 1950s (Garrett et al. 1992, p. 266; Brune 1981, p. 275). Based on this information and the longitudinal distribution of the fish in Pinto Creek and San Felipe Creek, we estimate that the critical habitat extends approximately 18.8 stream km (about 11.7 stream mi) downstream from Las Moras Spring to the Standard Pacific Railroad bridge crossing.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Dionda diaboli critical habitat consists of five components (73 FR 46988-47026):

(1) Streams characterized by: (A) Areas with slow to moderate water velocities between 10 and 40 cm/ second (4 and 16 in/second) in shallow to moderate water depths between approximately 10 cm (4 in) and 1.5 m (4.9 ft), near vegetative structure, such as emergent or submerged vegetation or stream bank riparian vegetation that overhangs into the water column; (B) Gravel and cobble substrates ranging in diameter between 2 and 10 cm (0.8 and 4 in) with low or moderate amounts of fine sediment (less than 65 percent stream bottom coverage) and low or moderate amounts of substrate embeddedness; and (C) Pool, riffle, run, and backwater components free of artificial instream structures that would prevent movement of fish upstream or downstream.

(2) High-quality water provided by permanent, natural flows from groundwater spring and seeps characterized by: (A) Temperature ranging between 17 °C and 29 °C (63 °F and 84 °F); (B) Dissolved oxygen levels greater than 5.0 mg/l; (C) Neutral pH ranging between 7.0 and 8.2; (D) Conductivity less than 0.7 mS/cm and salinity less than 1 ppt; (E) Ammonia levels less than 0.4 mg/ l; and (F) No or minimal pollutant levels for copper, arsenic, mercury, and cadmium; human and animal waste products; pesticides; fertilizers; suspended sediments; and petroleum compounds and gasoline or diesel fuels.

(3) An abundant aquatic food base consisting of algae attached to stream substrates and other microorganisms associated with stream substrates.

(4) Aquatic stream habitat either devoid of nonnative aquatic species (including fish, plants, and invertebrates) or in which such nonnative aquatic species are at levels that allow for healthy populations of Devils River minnows.

(5) Areas within stream courses that may be periodically dewatered for short time periods, during seasonal droughts, but otherwise serve as connective corridors between occupied or seasonally occupied areas through which the species moves when the area is wetted.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the areas occupied by the species at the time of listing contain the physical and biological features that are essential to the conservation of the species and that may require special management considerations or protections. We provide a summary discussion below of the special management needs for the Devils River, San Felipe Creek, and Pinto Creek stream segments. For additional information regarding the threats to the Devils River minnow and the needed management strategies to address those threats, see the Devils River Minnow Recovery Plan (Service 2005, pp. 1.7–1– 1.7–7; 1.8–1–1.8–4; 2.5–1–2.5–5). The following special management needs apply to all three stream segments, Devils River, San Felipe Creek, and Pinto Creek, and will be further discussed for each stream segment in the ‘‘Critical Habitat Designation’’ section below. a. Groundwater Management. The waters that produce all three stream segments issue from springs that are supported by underground aquifers, generally some portion of the Edwards-Trinity Aquifer or the Edwards

Aquifer (Ashworth and Stein 2005, pp. 16–33; Barker and Ardis 1996, pp. B5-B6; Brune 1981, pp. 274–277, 449–456; Green et al. 2006, pp. 28–29; LBG-Guyton Associates 2001, pp. 5–6; PWPG 2006, pp. 3–5, 3–6, 3–30; USGS 2007, p.2). Regional groundwater flow in this area is generally from north to south (Ashworth and Stein 2005, Figure 8). These aquifers are currently pumped to provide water for human uses including agricultural, municipal, and industrial (Ashworth and Stein 2005, p. 1; Green et al. 2006, pp. 28–29; LBG-Guyton Associates 2001, pp. 22–27; PWPG 2006, pp. 3–14, 3–15). Some parts of these aquifers have already experienced large water level declines due to a combination of pumping withdrawals and regional drought (Barker and Ardis 1996, p. B50). There are a number of preliminary project plans to significantly increase the amount of groundwater pumped in this area to export it to other metropolitan centers (HDR Engineering Inc. 2001, p. 1–1; Khorzad 2002, p. 19; PWPG 2006, pp. 4– 54). If the aquifers are pumped beyond their ability to sustain levels that support spring flows, these streams will no longer provide habitat for the Devils River minnow (Ashworth and Stein 2005, p.34; Edwards et al. 2004, p. 256; Garrett et al. 2004, pp. 439–440). Flow reductions can have indirect effects on fishes by impacting thermal regimes because higher water volumes buffers against temperature oscillations (Hubbs 1990, p. 89). Groundwater pumping that could affect stream flows within the Devils River minnow’s range is subject to local management control. State or Federal agencies do not control groundwater. Local groundwater conservation districts and groundwater management areas are the method for groundwater management in Texas and essentially replace the rule of capture where they exist (Caroom and Maxwell 2004, pp. 41–42; Holladay 2006, p. 3). Most districts are created by action of the Texas Legislature (Lesikar et al. 2002, p. 13). The regulations adopted by local groundwater conservation districts vary across the State and often reflect local decisions based on regional preferences, geologic limitations, and the needs of citizens (Holladay 2006, p. 3). The KCGCD is a local authority with some regulatory control over the pumping and use of groundwater resources in Kinney County (Brock and Sanger 2003, p. 42– 44). The KCGCD intends to manage the groundwater in Kinney County on a sustainable basis and yet beneficially use the groundwater without exploiting or adversely affecting the natural flow of the intermittent streams, such as Pinto Creek. Additional scientific information is needed on the geology and hydrology in Kinney County to increase the knowledge on the relationships of groundwater and stream flows. The 16 groundwater management areas in Texas include all of the state’s major and minor aquifers. Each GMA is required to determine a future desired groundwater condition for their aquifers. Based on the desired future condition specified, the Texas Water Development Board determines a managed available groundwater level for the groundwater management area. Lands outside of a groundwater conservation district, such as Val Verde County, are not subject to groundwater pumping regulations unless a landowner seeks State funding for a groundwater project. In this case, the project must be included in the groundwater management area’s regional water plan. The total groundwater allotments permitted by the groundwater management area must not exceed its managed available groundwater level. Val Verde is Groundwater Management Area 7 and Kinney County is within Groundwater Management Areas 7 and 10. Currently, there is no groundwater district in Val Verde County. Absent a local groundwater district, groundwater resources in Texas are generally under the ‘‘Rule of Capture,’’ (Holladay 2006, p. 2; Potter 2004, p. 9) or subject to the groundwater management area plans. The rule of capture essentially provides that groundwater is a privately owned resource and, absent malice or willful waste, landowners have the right to take all the water they can capture under their land (Holladay 2006, p. 2; Potter 2004, p. 1). The regional water plan adopted by the Plateau Regional Water Planning Group for this area recognizes that groundwater needs to be managed for the benefit of spring flows (PWPG 2006, p. 3–30) and that groundwater use should be limited so that ‘‘base flows of rivers and streams are not significantly affected beyond a level that would be anticipated due to naturally occurring conditions'' (Ashworth and Stein 2005, p. 34; PWPG 2006, p. 3–8). The Plateau Regional Water Plan is a non-regulatory water planning document for a 6-county area (including both Val Verde and Kinney counties) that maps out how to conserve water supplies, meet future water supply needs, and respond to future droughts. Special management efforts are needed across the range of the Devils River minnow to ensure that aquifers are used in a manner that will sustain spring flows and provide water as an essential physical feature for the species. We would like to work cooperatively with landowners, conservation districts, and others to assist in accomplishing these management needs. b. Nonnative Species. Controlling existing nonnative species and preventing the release of new nonnative species are special management actions needed across the range of the Devils River minnow. The best tool for preventing new releases is education of the public on the problems associated with nonnative species (Aquatic Nuisance Species Task Force 1994, pp. 16–17). Current nonnative species issues have been cited for possible impacts to the Devils River (smallmouth bass) and San Felipe Creek (armored catfish) (Lopez-Fernandez and Winemiller 2005, p. 247; Thomas 2001, p. 1; Robertson and Winemiller 2001, p. 220). The armored catfish may already be impacting Devils River minnows in San Felipe Creek through competition for common food resources of attached algae and associated microorganisms (Lopez-Fernandez and Winemiller 2005, p. 250). Hoover et al. (2004, pp. 6–7) suggest that nonnative catfishes in the family Loricariidae, such as armored catfish, will impact stream systems and native fishes by competing for food with other herbivores, changing plant communities, causing bank erosion due to burrowing in stream banks for spawning, incidentally ingesting fish eggs, and directly preying on native fishes (Wiersma 2007, p. 5). Problematic, nonnative species have not been documented in Pinto Creek. c. Pollution. Special management actions are needed to prevent point and nonpoint sources of pollution entering the stream systems where the Devils River minnow occurs. Devils River and Pinto Creek are generally free of threats from obvious sources of pollution. San Felipe Creek is in an urban environment where threats from human-caused pollution are substantial. Potential for spill or discharge of toxic materials is an inherent threat in urban environments. In addition, there are little to few current controls in the City of Del Rio to minimize the pollutants that will run off into the creek during rainfall events from streets, parking lots, roof tops, and maintained lawns from private yards and the golf course (Winemiller 2003, p. 27). All of these surfaces will contribute pollutants (for example, fertilizers, pesticides, herbicides, petroleum products) to the creek and potentially impact biological functions of the Devils River minnow. In addition, trash is often dumped into or near the creek and can be a source of pollutants (City of Del Rio 2006, p. 11). Special management by the City of Del Rio is needed (City of Del Rio 2006, p. 13) to institute best management practices for controlling pollution sources that enter the creek and maintain the water quality at a level necessary to support Devils River minnow. Special management actions may be needed to ensure appropriate best management practices are used in the exploration and development of petroleum resources in the watersheds of the Devils River minnow, particularly the Devils River (Smith 2007, p. 1). This will ensure that site development and drilling practices do not impact groundwater or surface water quality in habitats of the Devils River minnow. d. Stream Channel Alterations. The stream channels in the three streams where Devils River minnow occurs should be maintained in natural conditions, free of instream obstructions to fish movement and with intact stream banks of native vegetation. Devils River and Pinto Creek are generally free of stream channel alterations; however, San Felipe Creek has been altered by diversion dams, bridges, and armoring of stream banks (replacing native vegetation and soils with rock or concrete). Special management is needed in all three occupied streams to protect the integrity of the stream channels for the maintenance of the PCEs.

Life History

Feeding Narrative

Adult: Based on their long coiled intestinal tract, species of the genus Dionda are considered to feed primarily on algae, although larval stages may prey on invertebrates (Balon 1985; Gerking 1994) (USFWS, 2005).

Reproduction Narrative

Adult: The generation time probably is only 1-2 years (NatureServe, 2015). Based on laboratory observations, the species reproduces by releasing eggs that adhere within gravel and hatch as early as 2 weeks after deposition during the spring and summer (USFWS, 2008). The life expectancy of the fish has not been studied, but based on similar minnows it can be estimated at one to two years (C. Hubbs, University of Texas at Austin, pers. comm. 2003) (USFWS, 2005).

Geographic or Habitat Restraints or Barriers

Adult: Reduced water quality (USFWS, 2008); dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2008)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 2008)

Habitat Narrative

Adult: This species is most abundant in fast-flowing, clear, spring-fed water over gravel. It is a channel inhabitant under normal flow regimes, but may occur in shallow riffles after flooding. In the headwaters of Pinto Creek, it was found in flowing, spring-fed waters over gravel-cobble substrates, usually associated with aquatic macrophytes (Garrett et al. 2004). In San Felipe Creek, López-Fernández and Winemiller (2005) found that D. diaboli was restricted to creek habitats and did not occur in the spring outflow channels; in some areas it was most numerous where aquatic macrophytes were scarce or absent, but these areas had abundant overhanging riparian vegetation. Separation barriers include dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). The Devils River minnow is only found in spring-fed streams with shallow to moderate depths and slow to moderate water velocity, over gravel substrates, and in or nearby emergent or submerged vegetation or similar structure from stream bank vegetation that extends into the water. To persist, the Devils River minnow requires specific conditions of water chemistry, temperature, depth, and velocity, in addition to particular cobble to gravel substrates for breeding and vegetative cover for protection from predation (73 FR 46988). Devils River minnows no longer occur in streams with reduced water quality (USFWS, 2008).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015)

Population Information and Trends

Population Trends:

Decline of 30 - 70% (NatureServe, 2015)

Species Trends:

Stable in U.S. (NatureServe, 2015)

Number of Populations:

~6 (NatureServe, 2015)

Population Size:

Unknown; presumed several thousand (NatureServe, 2015)

Population Narrative:

Extent of occurrence, area of occupancy, number of subpopulations, and population size have substantially declined. This species has experienced a long term decline of 30-70%. The total adult population size is unknown but presumably at least several thousand. Some recent collections included hundreds of individuals (see USFWS 2005). The known distribution includes not more than about a half dozen extant populations (USFWS 1999, 2005; Garrett et al. 2004). Devils River minnow (Dionda diaboli) populations were found to be relatively stable in abundance at various localities throughout their current U.S. range, based on multi-year monitoring studies in the Devils River, San Felipe Creek, and Pinto Creek (Desert Fishes Council 2003 meeting abstracts) (NatureServe, 2015).

Threats and Stressors

Stressor: Habitat loss and modification (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Habitat loss and modification throughout a large portion of the range of the Devils River minnow has resulted in the fragmentation and contraction of the species' range. The distribution of the minnow in the Devils River was reduced by the impoundment of Amistad Reservoir in 1968. The inundation of the lower portion of the river by Amistad Reservoir eliminated important habitat for Devils River minnow, changing a lotic environment (fast flowing water) to a lentic environment (non-flowing or slow flowing water). These alterations resulted in the elimination of Devils River minnow in the lower portions of the Devils River. Las Moras Creek downstream from the spring is degraded from pollution and channelization (Garrett et al. 1992). This combination of habitat alteration (periodic loss of spring flow and channel modification) and water quality degradation (from chlorination) is the most likely cause for the extirpation of the species from Las Moras Creek. The stream channels in San Felipe Creek in Del Rio and Las Moras

Creek in Brackettville have been modified for bank stabilization, flood control, public access, road bridges, and diversion of irrigation water. Non-native vegetation dominates much of the riparian corridors. In some areas, these changes may alter the habitat for the Devils River minnow. Aquatic ecosystems in the northern regions of Chihuahua and Coahuila, Mexico, are undergoing changes from increasing use of groundwater and surface water (Contreras and Lozano 1994). Watersheds throughout the Río Salado Basin have been degraded from agricultural land uses and industrial development resulting in channelization and pollution of the creeks that provide habitat for the Devils River minnow (Contreras-Balderas et al. 2001). The Río Sabinas, in particular, has been noted for decreasing stream flows (Contreras and Lozano 1994) (USFWS, 2005).

Stressor: Spring flow declines (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Groundwater discharge declines from springs and seeps are major threats to the Devils River minnow throughout its range (Garrett et al. 1992, Contreras-Balderas and Lozano-Vilano 1994). Increases of water withdrawals from aquifers that support spring flows in the range of the Devils River minnow (including the Devils River, San Felipe Creek, Sycamore Creek, Pinto Creek, and Las Moras Creek) could result in reduction of critical spring flows or the drying of streams that support the species. As spring flows decline due to drought or groundwater lowering from pumping, habitat for the Devils River minnow is reduced and could eventually cease to exist (USFWS, 2005).

Stressor: Water quality degradation (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Water quality degradation and contamination are inherent threats to the population in San Felipe Creek because of its urban location. Studies by the Texas Commission on Environmental Quality (TCEQ), formerly the Texas Natural Resource Conservation Commission, (TNRCC 1994, 1996) and the International Boundary and Water Commission (IBWC 1994) found elevated levels of nitrates, phosphates, and orthophosphate in San Felipe Creek, indicating potential water quality problems. Land uses in the immediate area of the springs, such as runoff from the municipal golf course, may have contributed to these conditions. Catastrophic events, such as a large contaminant spill from a transportation vehicle at a bridge crossing, also threaten the species in San Felipe Creek. Continued swimming pool maintenance practices may be negatively affecting the water quality in Las Moras Creek and degrading the stream habitat (USFWS, 2005).

Stressor: Introduced species (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: The Devils River minnow is threatened by the presence of introduced fishes. Fish collections by G. Garrett in 1997 from San Felipe Creek revealed for the first time the presence of armored catfish (Hypostomus sp.). Collections in 2001 to 2003 have confirmed that armored catfish are reproducing and are abundant in San Felipe Creek (Lopez-Fernandez and Winemiller

2005). Non-native fishes could pose a major threat to the Devils River minnow population in San Felipe Creek by degrading physical habitat (eating algal cover and uprooting aquatic plants), competing for food (Lopez-Fernandez and Winemiller 2005), and preying on eggs by incidental ingestion (Hoover et al. 2004). The Devils River minnow evolved in the presence of native fishes that consume other fishes, such as largemouth bass (Micropterus salmoides). However, the smallmouth bass is an aggressive, non-native predator, and it is known to affect other native fish communities (Taylor et al. 1984, Moyle 1994). The Devils River minnow is within the size class of small fishes that are susceptible to predation by smallmouth bass. Another aquatic animal introduced into San Felipe Creek is the Asian snail, Melanoides tuberculata. This snail serves as an intermediate host of a gill fluke that has been documented to harm other fishes in San Felipe Creek (McDermott 2000). The effects this parasite may have on Devils River minnow are unknown (USFWS, 2005).

Stressor: Stochastic events (USFWS, 2005)
Exposure:
Response:
Consequence:
Narrative: Populations of Devils River minnow are restricted to small reaches of streams that are disconnected from one another. Amistad Reservoir has fragmented the population of the fish in the Devils River from other populations to the east. Hydrologically there are connections between San Felipe, Sycamore, Pinto, and Las Moras creeks via the Rio Grande. However, because the fish are (or were) restricted to upstream portions of these streams, and the Rio Grande is being reduced in water quality and quantity, it is highly unlikely that any genetic exchange is occurring between these populations. There is also likely no genetic exchange between U.S. and any extant Mexican populations of Devils River minnow, since they are separated by a large distance. These populations are highly vulnerable to events that could cause substantial loss of natural genetic diversity or local extirpations (such as stream desiccation or contamination). The current distribution would not allow natural recolonization from other populations. The overall risk of extinction is elevated due to such factors as the small number of fragmented populations in relative close proximity, the small fluctuating population sizes, and the short species life span (for a sample of discussions on extinction risk see Davies et al. 2004, Fagan et al. 2002, Ogrady et al. 2004, and Pimm et al. 1988) (USFWS, 2005).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. Population monitoring verifies stable or increasing population trends for Devils River minnow for at least 10 years throughout its range including Devils River (middle portion), San Felipe Creek, Sycamore Creek, and Pinto Creek in Texas. If reestablishment is scientifically feasible, populations should be restored in Las Moras Creek. The status of populations in the Rio Salado drainage in Mexico should also be confirmed (USFWS, 2008).

2. Adequate flows in streams supporting Devils River minnow have been ensured, including Las Moras Creek (if reestablishment is feasible), through State or local groundwater management plans, water conservation plans, drought contingency plans, regulations, or equivalent binding

documents (USFWS, 2008).

3. Protection of surface water quality, including the protection of the quality of groundwater sources of surface water flows, is ensured throughout the range of Devils River minnow by demonstrated compliance with water quality standards and implementation of water quality controls, particularly in urban areas such as the cities of Del Rio and Brackettville (USFWS, 2008).

4. Management and control of non-native species by local, regional, State, and Federal authorities are demonstrated to be successful (USFWS, 2008).

Recovery Actions:

- Maintain and enhance Devils River minnow populations and habitats range-wide (USFWS, 2005).
- Establish additional Devils River minnow populations within the historic range (USFWS, 2005).
- Maintain genetic reserves of the Devils River minnow through captive propagation until no longer needed (USFWS, 2005).
- Disseminate information about Devils River minnow conservation (USFWS, 2005).
- Work with the local communities in Val Verde and Kinney counties to find acceptable groundwater management strategies to allow aquifers to be maintained at levels that ensure spring flows into streams that serve as habitat for Devils River minnows (USFWS, 2008).
- Work with TPWD and U.S. Geological Survey to determine the necessary instream flow levels for maintenance of Devils River minnow habitat across its range (USFWS, 2008).
- Determine methods, in cooperation with TPWD, to control the nonnative armored catfish in San Felipe Creek (and implement the methods if found feasible) (USFWS, 2008).
- Work with the Fort Clark Springs Association, the City of Brackettville, the Kinney County Groundwater Conservation District, TPWD, and landowners to develop a reintroduction plan and landowner agreements (either using safe harbor agreements, preferably, or a 10(j) experimental population designation) to restore Devils River minnow to Las Moras Creek (USFWS, 2008).
- Work with TPWD and private landowners along Sycamore Creek, to conduct additional fish surveys to determine the occupancy of the stream by Devils River minnow and whether it is appropriate to consider for reintroductions. If so, the same efforts will be needed as documented under #3 above and could be done concurrently (USFWS, 2008).
- Assist the City of Del Rio, as needed, to complete an appropriate master plan for San Felipe Creek (USFWS, 2008).

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Designation of Critical Habitat for the Devils River Minnow

Final Rule. 73 FR 46988-47026 (August 12, 2008).

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SPECIES ACCOUNT: *Elassoma alabamae* (Spring pygmy sunfish)

Species Taxonomic and Listing Information

Listing Status: Threatened; 12/2/2013; Southeast Region (R4) (USFWS, 2015)

Physical Description

A fish (pygmy sunfish). Average adult body size is 17.4 mm SL, maximum 25 mm SL (Mayden 1993). (NatureServe, 2015)

Taxonomy

MtDNA data indicate that Elassoma is monophyletic; see Quattro et al. (2001) for information on phylogenetic relationships among the six species in this genus (E. alabamae is widely divergent; E. boehlkei and E. okatie are sister taxa related to the widespread E. evergladei). (NatureServe, 2015)

Historical Range

Originally this species occurred in three separate spring systems, all draining into the Tennessee River, in Lauderdale and Limestone counties, northern Alabama (Boschung and Mayden 2004). (NatureServe, 2015)

Current Range

Currently it occurs in Limestone County in the Beaverdam-Moss Spring/Swamp complex, including Beaverdam Spring, Moss Spring and its spring run to Beaverdam Creek, and Lowe's Ditch (an artificial irrigation ditch formed by dynamite blasting), and also in the Pryor Springs system, a former habitat into which the species was restocked in the 1980s (Boschung and Mayden 2004); however this population is now extirpated (Center for Biological Diversity 2009). The population that formerly inhabited Cave Spring, Lauderdale County, is extirpated. (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 7/27/1979.

Legal Description

On October 2, 2012, the U.S. Fish and Wildlife Service (Service) designated proposed critical habitat for Elassoma alabamae (Spring Pygmy Sunfish) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two critical habitat units (CHUs) in Alabama (77 FR 60180-60206).

Critical Habitat Designation

The proposed critical habitat designation for Elassoma alabamae includes two CHUs in Limestone County, Alabama (77 FR 60180-60206).

Unit 1: Beaverdam Spring/Creek, Limestone County, Alabama.

Unit 2: Pryor Spring/Pryor Branch, Limestone County, Alabama.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Elassoma alabamae proposed critical habitat consists of four components in Alabama (77 FR 60180-60206):

(i) Spring system. Springs and connecting spring-fed reaches and wetlands that are geomorphically stable and relatively low-gradient. This includes headwater springs with spring heads, spring runs, and spring pools that filter into shallow, vegetated wetlands.

(ii) Water quality. Yearly averages of water quality with optimal temperatures of 57.2 to 68 °F (14 to 20 °C) and not exceeding 80 °F (26.7 °C); pH of 6.0 to 7.7; dissolved oxygen of 6.0 parts per million (ppm) or greater; specific conductivity no greater than 300 micro Siemens per centimeter at 80 °F (26.7 °C); low concentrations of free or suspended solids with turbidity measuring less than 15 Nephelometric Turbidity Units (NTU) and 20 milligrams per liter (mg/l) total suspended solids (TSS).

(iii) Hydrology. A hydrologic flow regime (magnitude, frequency, duration, and seasonality of discharge over time) necessary to maintain spring habitats. The instream flow from groundwater sources (springs and seeps) maintains an adequate velocity and a continuous daily discharge from the aquifer that allows for connectivity between habitats. Instream flow is stable and does not vary during water extraction, and the aquifer recharge maintains adequate levels to supply water flow to the spring head. The flow regime does not significantly change during storm events.

(iv) Vegetation and Prey Base. Aquatic, emergent and semi-emergent vegetation along the margins of spring runs and submergent vegetation that is adequate for breeding, reproducing, and rearing young; providing cover and shelter from predators; and supporting the prey base of aquatic macroinvertebrates eaten by spring pygmy sunfish. Important species of submergent and emergent vegetation include clumps and stands of Sparganium spp. (bur reed), Ceratophyllum spp. (coontail), Nasturtium officinale (watercress), Juncus spp. (rush), Carex spp. (sedges), Nuphar luteum (yellow pond lily), Myriophyllum spp. (parrot feather), Utricularia spp. (bladderwort), Polygonum spp. (smartweed), Lythrum salicaria (purple loosestrife), and Callitriche spp. (water starwort).

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. We find that the essential features within the area occupied at the time of listing may require special management consideration or protection due to threats to spring pygmy sunfish and or its habitat. The sole proposed unit that is occupied is adjacent to roads, homes, or other manmade structures in which various activities in or adjacent to the critical habitat unit may affect one or more of the physical and biological features. The features essential to the conservation of this species are the spring systems that may require special management considerations or protection to reduce the following threats or potential threats: Reduction of water quantity of the groundwater/ surface hydrology by water extraction from springs or the aquifer that provides water to the spring, and surface flow to Beaverdam Creek and Pryor Branch; changes in the composition and abundance of vegetation in the spring; alteration of the bottom substrate and normal sinuosity of the system from fill material within the spring systems and spring-fed wetlands for development projects; degradation of water quality from uncontrolled discharge of stormwater draining agricultural fields, roads, bridges, and urban areas; careless agricultural practices including unmanaged livestock grazing; and road, bridge, and utility easement maintenance (e.g., use of herbicides and resurfacing or sealant materials). Management activities that could ameliorate these threats or potential threats include, but are not limited to: Establishing permanent conservation easements or land acquisition to protect the species on private lands; establishing additional conservation agreements on private lands to identify and reduce threats to the species and its features; minimizing habitat disturbance, fragmentation, and destruction by maintaining suitable fish passage structures under roads; providing significant buffers around the spring components such as the spring head, spring pool, and spring run; monitoring and regulating the withdrawal and use of groundwater and surface water of the Beaverdam Spring/ Creek system; preventing the diminishing of the aquifer recharge area by increasing the pervious area for percolation of rainfall back into the aquifer; limiting impervious substrates; and minimizing water quality degradation by stormwater runoff with catchment basins, vegetated bioswales, and other appropriate best management practices.

Life History

Feeding Narrative

Adult: This species prey on invertebrates. Vegetation is important to maintaining habitat for an invertebrate prey base (USFWS, 2013).

Reproduction Narrative

Adult: Spawning occurs mainly in March and April. Eggs are attached to aquatic vegetation (usually Ceratophyllum) above the substrate (Mayden 1993). Evidently, adults spawn at one year of age and die within a few days to months after spawning (Mayden 1993), but fishes in aquaria may live to spawn in their second year (see Boschung and Mayden 2004). (NatureServe, 2015). The spring pygmy sunfish has low fecundity (reproductive capacity) indicating a species that is adapted to and requires highly stable groundwater dependent habitats and an ecological dependence upon unchanging habitats in early life stages (Rakes in litt. 2012). Adults reproduce from January to October. Spawning begins in March and April, when water quality parameters are within a suitable range (pH of 6.0 to 7.7 and water temperatures of 57.2 to 68 degrees Fahrenheit (°F) (15 to 20 degrees Celsius (°C)) (Sandel 2007, p. 2; Mettee 2008, p. 36; Petty et al. 2011, p. 4). Spring pygmy sunfish produce about 65 eggs. Compared to other pygmy sunfishes, spring pygmy sunfish have the highest average number of eggs per spawn, but the lowest percentage of egg survival, which increases the species' vulnerability (Mettee 1974, p. 38) (USFWS, 2013).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Very narrow (inferred from NatureServe, 2015 and USFWS, 2013)

Tolerance Ranges/Thresholds

Adult: Low (inferred from USFWS, 2013; see reproduction narrative)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Dependency on Other Individuals or Species for Habitat

Adult: Ceratophyllum echinatum, Myriophyllum heterophyllum, and Hydrilla verticillata (USFWS, 2013)

Habitat Narrative

Adult: Habitat includes springs, spring outflows, and associated swamps; areas of clear water with fine sand, clay, mud, or limestone substrate and abundant and thick, rooted aquatic vegetation (Boschung and Mayden 2004); shoreline areas grassy/weedy and marshy, with sparse to abundant hardwood trees. In the Moss Spring and Beaverdam Creek/Swamp area, this species is most commonly found above the substrate in association with rooted submergent vegetation (Mayden 1993). Apparently it uses different spring and swamp macrohabitats at different times of the year. Flows from springs may be crucial during periods of drought. Separation barriers are created by dams lacking a suitable fishway; high waterfalls; upland habitat. (NatureServe, 2015). The species is most abundant at the spring outflow or water emergence (spring head) from the ground and spring pool area (Sandel 2009, p. 14), typically occupying areas with water depths from 5 to 40 inches (in) (13 to 102 centimeters (cm)) and rarely in the upper 5 in (13 cm) of the water column. The spring pygmy sunfish prefers patches of dense filamentous submergent vegetation, including Ceratophyllum echinatum (spineless hornwort), Myriophyllum heterophyllum (two-leaf water milfoil), and Hydrilla verticillata (native hydrilla) (USFWS, 2013).

Dispersal/Migration

Motility/Mobility

Adult: High (inferred from NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Moderate (inferred from NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Although members of this group vary in size and probably in typical movement distances, it is likely that even the smallest centrarchids occasionally disperse as far as do large centrarchids. (NatureServe, 2015)

Population Information and Trends

Population Trends:

Declining (NatureServe, 2015)

Species Trends:
Declining (NatureServe, 2015)

Number of Populations:
1 (NatureServe, 2015) 1 - 5 (NatureServe, 2015)

Population Size:
2500 - 10,000 individuals (NatureServe, 2015)

Adaptability:
Low (inferred from NatureServe, 2015)

Population Narrative:
Known populations were increasing in the mid-1990s (USFWS 1996). Subsequently the species experienced major declines in extent of occurrence, area of occupancy, and number of subpopulations. Known populations each exceed 1000 individuals (USFWS 1996). This species is locally common; it is the most numerous fish species in the Moss Spring complex (see Conway and Mayden 2006). This species exhibits an annual life cycle; population size probably exhibits significant fluctuations. This species is represented by an extant occurrence in only one spring complex (Center for Biological Diversity 2009) (NatureServe, 2015).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The spring pygmy sunfish and its habitat are currently facing the threats of both declining water quality and quantity. Excessive groundwater usage, and the resultant reduction of the water levels in the aquifer/recharge areas and decreased spring outflow in the Beaverdam Spring/Creek system, is believed to have negatively impacted the spring pygmy sunfish and its habitat. Contamination of the recharge area and aquifer from the intensive use of chemicals (i.e., herbicides, pesticides, and fertilizers) within the spring pygmy sunfish’s habitat poses a threat to the species’ survival. Ongoing stormwater discharge from agricultural lands and urban sites compounds the water quality degradation by increasing sediment load and depositing contaminants into surface and groundwater sources. In addition, the large-scale residential and industrial development planned adjacent to the Beaverdam Spring/Creek system will likely exacerbate the decreasing water quantity and quality issues within the habitat of the spring pygmy sunfish’s single metapopulation. Overgrazing by livestock and land clearing near and within the spring systems reduces the vegetation in the spring and increases stormwater and sediment runoff, posing a threat to the population, particularly in the middle and lower portions of its range (USFWS, 2013).

Stressor: Habitat fragmentation (USFWS, 2013)
Exposure:
Response:

Consequence:
Narrative: Impediments to migration, connectivity, and gene flow between or within spring systems are threats to maintaining genetic diversity in the spring pygmy sunfish. Habitat connectivity is critical to maintaining heterozygosity (genetic diversity) within populations of the species and reducing inbreeding, thereby maintaining the integrity of the population (Hallerman 2003, pp. 363–364). Connectivity of spring pygmy sunfish habitats is also necessary for improvement in desired aquatic vegetation, water quality through flushing and diluting pollutants and increasing water quantity, and linking spring segments together. Connectivity maintains water flow between Beaverdam Spring/Creek habitats and allows for potential colonization of unoccupied areas when conditions become favorable for the species and for the necessary aquatic vegetation needed by the species. Localized environmental changes caused by agriculture, urbanization, and other anthropogenic disturbances of the spring systems throughout the watersheds of the Eastern Highland Rim have exacerbated fragmentation of spring habitat (Sandel 2008, pp. 2–4, 13; 2011, pp. 3–6) and reduced the desired vegetation necessary for the species' survival and recovery. Over time, this fragmentation of the spring pygmy sunfish's habitat will impose negative selective pressures on the species' populations, such as genetic isolation; reduction of space for rearing, recruitment, and reproduction; reduction of adaptive capabilities; and increased likelihood of local extinctions (Burkhead et al. 1997, pp. 397–399; Sandel 2011, pp. 8–10) (USFWS, 2013).

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: While we do not have specific information concerning the effect of climate change on spring pygmy sunfish and its habitat, we do know that climate affects groundwater budgets (inflow and outflow) by influencing precipitation and evaporation and, therefore, the rates and distribution of recharge of the aquifer. Climate also affects human demands for groundwater and affects plant transpiration from shallow groundwater in response to solar energy and changing depths to the water table (Likens 2009, p. 91). Long-term droughts impact groundwater by increasing groundwater extraction for public consumption and agriculture, which in turn do not replenish surface waters (Likens 2009, p. 91). The assessment of long-term impacts of projected changes in climate, population, and land use and land cover on regional water resources is critical to sustainable development, especially in the southeastern United States (Sun et al. 2008, pp. 1141–1157) (USFWS, 2013).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.

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SPECIES ACCOUNT: *Empetrichthys latos* (Pahrump poolfish)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; March 11, 1967 (32 FR 4001).

Physical Description

The Pahrump poolfish (Empetrichthys latos) is a small, relatively slender fish, reaching a maximum length of about 77 millimeters (3 inches). The poolfish has a slender, elongate body with dorsal and anal fins placed far back; a broad, upturned mouth; a dark, longitudinal streak (which tends to disappear in older, larger individuals); and an orange ring around the eyes. Poolfish lack pelvic fins, but the dorsal, anal, and caudal fins are bright orange-yellow when the fish are in an environment of optimal temperature and dissolved oxygen. The body of the poolfish is greenish-brown with black mottling, but males may be silver-blue without mottling during the spawning season. Females are typically larger than males (69 FR 17383; USFWS 1980).

Taxonomy

The Pahrump poolfish is one of two fish constituting the genus Empetrichthys in the family Cyprinodontidae. The other form, the Ash meadows killifish, Empetrichthys merriami Gilbert, became extinct in the late 1940s. There were three subspecies of Empetrichthys latos, each existing in a separate spring: E. l. latos, E. l. concavus, and E. l. pahrump. The last two fish are now extinct and E. l. latos disappeared from its native habitat at Manse Springs in August of 1975. The last representative of the genus Empetrichthys now exists only in transplanted populations (USFWS 1980).

Historical Range

The Pahrump poolfish is endemic to Manse Springs in Nye County, Nevada. In 1975, the Manse Springs dried up due to excess groundwater pumping, resulting in the loss of the only natural population of Pahrump poolfish (USFWS 2014).

Current Range

The Pahrump poolfish is endemic to the Pahrump Valley in southern Nye County, Nevada. Three populations of Pahrump poolfish have been established since their extirpation from Manse Springs: Corn Creek Spring on the Desert National Wildlife Range, north of Las Vegas, Nevada; Shoshone Springs southeast of Ely, Nevada; and an irrigation reservoir at Springs Mountain Ranch State Park west of Las Vegas, Nevada (USFWS 2014).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Juvenile: See adult life stage.

Adult: Pahrump poolfish are opportunistic omnivores that feed on a wide variety of available plant and animal material in the ponds they inhabit. They experience resource competition primarily from nonnative species, including goldfish, crayfish, and mosquitofish. Pahrump poolfish fry are active during the daytime and remain near the bottom or near other substrate; this location offers protection from predators and can be a source of food. Adult fish tend to be more active at night, and all fish are more active in summer and fall months (USFWS 1980).

Reproduction Narrative

Juvenile: See adult life stage.

Adult: Little is known about Pahrump poolfish reproduction. Demersal spawning occurs year-round, but appears to peak between March and April (USFWS 1980). During their breeding period, females seek seclusion for egg-laying in remote areas of the spring (USFWS 1980). One study found that female Pahrump poolfish produced between eight and 111 eggs (Deacon and Williams 2010). The presence of nonnative goldfish has been shown to negatively affect the Pahrump poolfish's reproductive potential (Deacon and Williams 2010). Sex ratios vary by population, with the male-to-female ratios of populations in Corn Creek, Mountain Ranch State Park, and Shoshone ponds ranging from 1:3 to 1:3.9 (Deacon and Williams 2010). The male-to-female ratio at Manse Spring was between 1:11 and 1:19; however, the study reporting this ratio included the caveat that the sex ratio calculation was not the primary purpose of the study, and the authors had therefore not controlled for sexual selection (Deacon and Williams 2010).

Spatial Arrangements of the Population

Juvenile: Juveniles and smaller fish inhabit shallower, more weedy areas, and use the near-surface layer.

Adult: Adults and larger fish inhabit more open and deep waters.

Environmental Specificity

Juvenile: Generalist, but prefers shallower and weedier areas and stays closer to the water's surface (USFWS 1980).

Adult: Generalist, but prefers more open and deeper waters (USFWS 1980).

Tolerance Ranges/Thresholds

Juvenile: These fish appear tolerant to variable temperatures, but their threshold temperatures are unknown.

Adult: These fish appear tolerant to variable temperatures, but their threshold temperatures are unknown.

Site Fidelity

Juvenile: High

Adult: High

Habitat Narrative

Juvenile: Juvenile Pahrump poolfish inhabit permanent, warm, shallow springs and reservoirs, including alkaline mineral springs and outflow streams. A water temperature of 24°C (76°F) is optimal, although they appear to be tolerant to variable temperatures (USFWS 1980). Juvenile fish inhabit shallower, weedier areas and remain closer to water's surface. The integrity of their habitat is threatened by introduced nonnative goldfish and crayfish, which compete for resources and prey on Pahrump poolfish (69 FR 17383).

Adult: Adult Pahrump poolfish inhabit permanent warm, shallow springs and reservoirs, including alkaline mineral springs and outflow streams. A water temperature of 24°C (76°F) is optimal, although they appear to be tolerant to variable temperatures (USFWS, 1980). Adult fish generally inhabit open and deeper waters (USFWS 1980). The integrity of their habitat is threatened by introduced nonnative goldfish and crayfish, which compete for resources and prey on Pahrump poolfish (69 FR 17383).

Dispersal/Migration

Motility/Mobility

Juvenile: Low, due to small habitat area available.

Adult: Low, due to small habitat area available.

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Nonmigratory, no seasonal movements.

Adult: Nonmigratory, no seasonal movements.

Dispersal

Juvenile: Low

Adult: Low

Immigration/Emigration

Juvenile: Species has been relocated, natural immigration/emigration unlikely.

Adult: Species has been relocated, natural immigration/emigration unlikely.

Dispersal/Migration Narrative

Juvenile: See adult life stage.

Adult: Pahrump poolfish have limited mobility due to the small size of their habitats and a lack of habitat connectivity. Individual Pahrump poolfish inhabit a single reservoir or spring for the duration of their lives. They are nonmigratory, have no seasonal movements, and do not disperse. They have been artificially introduced to new habitats in response to the loss of their historic habitat site, but natural immigration or emigration is highly unlikely.

Population Information and Trends

Population Trends:

Stable (Springs Mountain Ranch State Park, Corn Creek Springs); Declining (Shoshone Ponds Natural Area)

Species Trends:

Stable

Population Growth Rate:

Unknown at Corn Creek Springs, in decline at Shoshone Ponds Natural Area, stable at Springs Mountain Ranch State Park (69 FR 17383).

Number of Populations:

4 Refuge populations (USFWS, 2023)

Population Size:

At Spring Mountain Ranch State Park, the population was estimated to contain 16,775 individuals in 2003. The population at Corn Creek Springs is being rebuilt through reintroductions after being lost in the late 1990s due to the introduction of nonnative crayfish and goldfish. The population at Shoshone Ponds Natural Area was estimated to contain fewer than 1,000 individuals in 2003 (69 FR 17383).

Minimum Viable Population Size:

Three populations containing a minimum of 500 adults each (USFWS 1980).

Resistance to Disease:

Low

Adaptability:

Low

Additional Population-level Information:

Extirpated from its only known native habitat at Manse Spring, near Pahrump Nevada, in 1975, there are currently four refuge locations which contain Pahrump poolfish: 1) Corn Creek; 2) Shoshone Ponds; 3) Springs Preserve; and 4) Spring Mountain Ranch State Park (USFWS, 2023).

Population Narrative:

Pahrump poolfish occur in three populations: Springs Mountain Ranch State Park, Corn Creek Springs, and Shoshone Ponds Natural Area. The population at Springs Mountain Ranch State Park was stable and contained approximately 16,775 individuals in 2003 (69 FR 17383). The population at Corn Creek Springs is being rebuilt through introductions after being lost in the late 1990s due to the introduction of nonnative crayfish and goldfish. A survey in 2003 found that the population at Corn Creek Springs was still small and isolated. The population at Shoshone Ponds Natural Area was in decline and contained fewer than 1,000 individuals in 2003 (69 FR 17383). According to the Pahrump Killifish Recovery Plan, each population must contain a minimum of 500 adults to be considered viable (USFWS 1980).

Threats and Stressors

Stressor: Limited current range
Exposure: Small range
Response: Limited ability for population growth
Consequence: Species unable to reach target population goals
Narrative: Three separate populations of poolfish currently exist; however, only one is considered stable. Additionally, none of these populations currently occur at Manse Spring, its historic habitat. Establishing a population of poolfish at Manse Spring was identified as a high-priority objective of the Recovery Plan. However, recent residential development in and around Manse Ranch continues to modify the native habitat; future residential and commercial development in the Pahrump Valley may limit the available water resources and preclude the opportunity to reestablish a poolfish population in this location.

Stressor: Excessive groundwater withdrawals
Exposure: Groundwater withdrawal
Response: Desiccation of ponds
Consequence: Destruction of habitat, extirpation of species/populations
Narrative: The most critical threat to the poolfish has historically been the destruction of habitat through groundwater withdrawals, as demonstrated by the desiccation of the only historic habitat of the species. Adequate, reliable water sources are necessary to ensure that currently occupied ponds provide suitable habitat for the poolfish. Therefore, long-term declines in spring flows due to groundwater pumping from areas surrounding existing poolfish habitat remain a threat to all the populations.

Stressor: Competition and predation by nonnative crayfish, mosquitofish, and goldfish
Exposure: Nonnative competitors and predators
Response: Reduced food availability and predation
Consequence: Declining populations and pond extirpations
Narrative: Nonnative mosquitofish have historically caused declines in Pahrump poolfish populations through resource competition. Nonnative crayfish have historically threatened, and continue to threaten, poolfish populations through resource competition and predation. Nonnative goldfish also compete with and prey upon poolfish. Crayfish competition and predation, possibly compounded by goldfish competition and predation, led to the extirpation of poolfish from Corn Creek Springs in 1999, although poolfish were reintroduced to an isolated refugium in 2002. Resource competition and predation by nonnative species continues to be the most significant threat to Pahrump poolfish.

Stressor: Low population numbers
Exposure: Few individuals
Response: Vulnerability to inbreeding, catastrophes, and random events
Consequence: Increased risk of extirpation or extinction
Narrative: The low numbers of poolfish in their isolated habitats naturally make them vulnerable to risks associated with small, restricted populations. The elements of risk that are amplified in very small populations include (1) random demographic events (e.g., skewed sex ratios, high death rates, or low birth rates); (2) the effects of genetic drift (random fluctuations in gene frequencies) and inbreeding (mating among close relatives); (3) natural catastrophes (floods, fires, droughts, etc.) at random intervals; and (4) deterioration of environmental quality.

Recovery

Reclassification Criteria:
Establish at least three viable, reproducing populations of at least 500 adults per population for a 3-year period.

Delisting Criteria:
In addition to meeting the Reclassification Criteria, Delisting Criteria include sustaining 500 adults per population for an additional 3-year period (6-year period total).

Recovery Actions:

- Preserve and protect existing transplanted Pahrump poolfish populations and their habitats. In Corn Creek Springs, this includes managing competing and predatory species by eliminating exotic fishes, controlling bullfrogs and turtles, and controlling depredating birds; managing vegetation and water by installing concrete-lined inflow ditches, providing shelter over spring heads, controlling submerged and emergent vegetation, constructing an artificial spring in the middle of the pond, rehabilitating the lower pond, and securing the aquifer; and monitoring the population by establishing census techniques, recommending census personnel, and conducting a twice-yearly census. In Shoshone Ponds, this includes monitoring the population by establishing census techniques, recommending census personnel, and conducting a twice-yearly census; and managing pools as necessary by controlling water inflow and outflow, controlling vegetation, and securing the aquifer.
- Establish and protect viable, self-sustaining Pahrump poolfish populations in suitable new or restored habitats. A population at Spring Mountain Ranch (Krupp Ranch) should be established by removing exotic species as required, removing competing and predatory species, controlling vegetation as necessary, preparing and implementing a management plan, and ensuring protection of property and water rights. The Manse Spring population site should be established and restored by restoring habitat as necessary, enhancing biological factors (increase food supply, remove predators, etc.), restoring water supply and securing water availability, preparing and implementing a management plan, and acquiring control of property and water rights. Other suitable transplant sites and populations should be selected and established as needed. To accomplish this goal, the most suitable sites should be selected by examining candidate sites and evaluating them, specifying habitat selection, and determining the need for additional transplants; managing the site (i.e., restoring and/or enhancing chemical, physical, or biological parameters) by preparing a management plan and ensuring the protection of property and water rights; selecting transplant stock; and performing the transplant under proper authorization. If transplant populations are created, those populations should be monitoring by determining the population regime, fecundity, age-growth rate, size, and seasonal fluctuation.
- Conduct ecological studies and apply findings to the Pahrump poolfish and its habitats. Studies should include determining productivity of habitat, investigating habitat diversity, investigating water chemistry, determining yearly temperature regime, and determining volume configuration behavior. Pahrump poolfish behavioral studies should be conducted, including studies of competitive interaction with fish, frogs, birds, etc.; food and feeding habits; spawning ecology; water temperature preference; and substrate requirements. Data from studies should be analyzed, and management recommendations should be prepared and applied as appropriate. Finally, a study on the feasibility of restoring the type locality and Manse Springs should be conducted. This study should involve investigation of the

biological and physical factors in the area, determination of socioeconomic influences, and preparation of a feasibility report.

- Delineate essential habitat for species preservation.
- Enforce laws and regulations protecting Pahrump poolfish and its essential habitat. This measure includes enforcing state and federal regulations to protect the Pahrump poolfish; protecting Pahrump poolfish habitat and enforcing trespassing violations; and coordinating action of enforcement personnel and others, and advising them of Pahrump poolfish status and recovery effort.
- Inform public of Pahrump poolfish Status and Recovery Plan objectives. To achieve this goal, public awareness audiovisual programs and publications should be provided, including information for news media, TV, and radio releases; preparing and distributing a brochure on recovery plan rationale; and preparing appropriate articles for popular and scientific publications. Informational signs should be installed at essential habitat areas under state and/or federal management.
- Recovery Priority Number 11 (USFWS, 2018).
- RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS • Improve/restore refuge populations o Improve Shoshone Ponds Natural Area Maintain ponds and well outflow habitat by addressing issues such as grazing, aquatic vegetation removal, low dissolved oxygen levels, pond siltation, etc. o Develop management strategy for Spring Mountain Ranch State Park Remove/manage invasive species • Investigate potential for establishing or re-establishing populations o Develop interest in Manse Spring to allow reintroduction and protection of habitat Look at options – purchase, conservation easement, mitigation, etc. o Safe Harbor/Urban ponds (e.g. Springs Preserve) o Surrogate for Ash Meadows killifish (USFWS, 2018).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Maintain existing refuge habitats o Continue to improve and update refuge habitats to maintain long-term function. o Remove nonnative aquatic species, as needed. • Establish or re-establish populations o Develop interest, from both private and public entities, in Manse Spring to allow reintroduction and protection of habitat (e.g., conservation easement, purchase property). o Create additional populations using tools provided under Section 10 of the Act. • Continue to seek funding opportunities to facilitate actions which aid in the recovery of the species (USFWS, 2023).

Additional Threshold Information:

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See below.

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SPECIES ACCOUNT: *Eremichthys acros* (Desert dace)

Species Taxonomic and Listing Information

Listing Status: Threatened; December 10, 1985 (50 FR 50304).

Physical Description

The species' key identifying characteristic is a prominent horny sheath on each jaw. Coloration is olive-green above, with yellow reflections and indistinct black mottling on the sides; the belly is silvery. A green stripe is typically present on the sides. The maximum length is approximately 60 millimeters (mm) (2.4 inches [in.]) (USFWS 1997).

Taxonomy

The desert dace is the only member of the genus Eremichthys of the Cyprinidae family.

Historical Range

The extent of the historic range is unknown, although this fish likely occupied the spring systems in Soldier Meadow (USFWS 1997).

Current Range

This species currently inhabits eight major springs and approximately 5 kilometers (3.1 miles) of outflow stream habitat in the Soldier Meadows area of western Humboldt County, in northwestern Nevada, at elevations of 1,320 to 1,395 meters (4,330 to 4,577 feet). These springs and outflow streams are contained within an area of approximately 1,550 hectares (3,830 acres) (NatureServe 2015; USFWS 2012).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 12/10/1985.

Legal Description

On December 12, 1985, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Eremichthys acros (Desert dace) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU), in Nevada (50 FR 50304-50309).

The critical habitat designation for Eremichthys acrosincludes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Eremichthys acros.

Critical Habitat Designation

The critical habitat designation for Eremichthys acros includes one CHU, which encompass approximately eight of more than 20 springs in six square miles in Humboldt County, Nevada (50 FR 50304-50309).

Unit 1—Nevada, Humboldt County. Thermal springs and their outflows plus surrounding riparian areas for a distance of 50 feet from these springs and outflows in T40N. R25E. SW1/4 Section 5, NW1/4 NW1/4 Section 8, W1/2 Section 18, W1/2 SW1/4 Section 19; T40N, R24E. Section 23, N1/2 SE1/4 and S1/2 NE1/4 Section 21, SE1/4 Secrtion 25, and N1/2 Section 26.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Eremichthys acros critical habitat consists of one component (50 FR 50304-50309):

(1) Primary constituent elements of the habitat are considered to be quantity, and thermal and chemical quality of water in headpools and spring outflow streams: presence of a stable natural substrate supporting food plants for the fish: and length of outflow streams adequate for seasonal movements in response to changes of water temperature.

Life History

Feeding Narrative

Adult: Desert dace are opportunistic feeders. They are omnivorous and feed primarily on filamentous algae, diatoms, aquatic vegetation, zooplankton, snails, and aquatic insect larva. They compete for resources with nonnative fish. They can grow to a maximum length of 60 mm (2.4 in.) within 1 to 3 years (USFWS 2012).

Reproduction Narrative

Adult: Desert dace are oviparous. They have been documented in a laboratory setting to reach sexual maturity at 13 months of age. The length of their egg incubation is unknown but likely relatively short (2 weeks or less) (USFWS 1997). Sex ratios have been reported as 35 males for every 100 females. The lifespan is 1 to 3 years. (USFWS 2012). Reproduction has been observed throughout the spring and early summer, as well as in late fall, but may occur year-round. Spawning has been observed in warm springs of shallow depth, on a rocky/alluvial substrate (USFWS 1997).

Geographic or Habitat Restraints or Barriers

Adult: Desert dace occur in isolated spring systems, but some areas may be connected by surface flows during high runoff events.

Environmental Specificity

Adult: Narrow/specialist

Tolerance Ranges/Thresholds

Adult: High

Site Fidelity

Adult: High

Habitat Narrative

Adult: The desert dace occupies a freshwater habitat in warm springs and their outflow creeks (NatureServe 2015). They can tolerate a wide range of temperatures, ranging from 18 to 40 °C

(64.4 to 104 °F). Additionally, they require a stable, natural substrate that supports food and plants, and a stream outflow adequate in length to allow for seasonal movement in response to changes in water temperature (50 FR 50304). They inhabit several spring systems that are generally geographically isolated from one another, but may be connected seasonally by surface flows. Desert dace have the highest temperature tolerance of any minnow in western North America. Cooler habitats downstream of springheads generally have the highest fish densities. As stream temperatures decrease in winter, the species' range contracts upstream (50 FR 50304; NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: May move seasonally with greater hydrologic connectivity between discrete springs.

Dispersal

Adult: Low

Immigration/Emigration

Adult: No

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: Desert dace are moderately mobile in that they move freely within their spring ecosystems, which are at least seasonally discrete and relatively small. There may be some seasonal movement of individuals between distinct areas within the spring systems. However, dispersal is dependent upon hydrologic connectivity between spring systems during extremely wet conditions (NatureServe 2015).

Population Information and Trends

Population Trends:

Stable (NatureServe 2015).

Species Trends:

Relatively Stable (NatureServe 2015).

Number of Populations:

9 (USFWS 2012)

Population Size:

10,000 to 100,000 individuals (NatureServe 2015).

Adaptability:

Moderate

Additional Population-level Information:

Various sampling efforts and population metrics have been used to evaluate desert dace abundance. However, due to high variability in data collection methods, it is difficult to make direct or easy comparisons to evaluate changes in species abundance over time (USFWS 2012).

Population Narrative:

The desert dace is locally abundant in nine spring systems of Soldier Meadow. Current population data are not standardized and cannot be directly or easily compared. Nevada Deparment of Wildlife has conducted annual monitoring surveys at eight locations from 2016-2020 (NDOW 2020). Population estimates are not available, however over 4,000 fish were captured across all areas in 2020. The population in Fly Canyon is the only population that appears to have declined since it was first discovered in 2010. A fence was installed in 2015 to protect the springhead and system from over use by feral horses (NDOW 2020). Only three fish were captured during the 2020 monitoring survey but vegetation in the fenced area appears to be recovering. Future surveys will provide more information on the status of the desert dace in the Fly Canyon spring.

Threats and Stressors

Stressor: Recreational use of Soldier Meadow
Exposure: Bathing in hot springs, camping, all-terrain vehicle travel, and four-wheel driving.
Response: May threaten the desert dace and its habitat.
Consequence: Habitat degradation and increased stress on desert dace populations.
Narrative: There is currently one area in Soldier Meadow that receives substantial recreational use in the form of bathing, vehicle traffic, and camping. These activities may threaten the desert dace and its habitat (USFWS 2012).

Stressor: Nonnative fish species
Exposure: Introduction of nonnative fish to the spring systems is ongoing.
Response: Predation and competition for resources.
Consequence: Decreased population size and decreased reproductive success.
Narrative: The introduction of nonnative fish into the Soldier Meadow springs is an ongoing threat. Nonnative fish species may be predators of the desert dace, or may compete for available resources. This may cause a decrease in the population size and/or decreased reproductive success of the desert dace (USFWS 2012).

Recovery

Delisting Criteria:

Historical habitat in the one dewatered stream channel on public land (T40N, R24E, Sections 25 and 26) is restored so that it supports desert dace (USFWS 1997).

The desert dace populations in each of the eight historically occupied spring systems is stable or increasing in size and comprises two or more age classes for 3 years (USFWS 1997).

Reproduction and recruitment are documented from each historically occupied spring system with suitable water temperatures for 3 years (USFWS 1997).

Habitat modification, nonnative fishes, and parasites no longer threaten the long-term survival of the species (USFWS 1997).

Recovery Actions:

- Restore and manage desert dace habitats (USFWS 1997).
- Monitor desert dace populations (USFWS 1997).
- Provide public information and education (USFWS 1997).
- Restore flows to historical channels (USFWS 1997).
- Eliminate nonnative fish species, and restrict reentry with fish barriers (USFWS 1997).
- Camping areas should be relocated outside of riparian areas, and recreation areas should be managed to minimize impacts (USFWS 1997).
- Expand the Area of Critical Environmental Concern/Research Natural Area to include all known habitat for desert dace (USFWS 1997).
- Public information and outreach should have a focal point near the spring systems, especially those used for camping and bathing. Interpretive materials should emphasize the importance of all Soldier Meadows ecosystem components (USFWS 1997).

Additional Threshold Information:

-
-

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SPECIES ACCOUNT: *Erimonax monachus* (Spotfin Chub)

Species Taxonomic and Listing Information

Listing Status: Threatened/Experimental population; 10/11/1977, 08/12/2002, 04/08/2005, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

A small fish (chub or shiner) 9 cm in length (NatureServe, 2015).

Taxonomy

This species was removed from the genus Hybopsis and placed in the genus (formerly subgenus) Cyprinella by Coburn and Cavender (1992) and in the 1991 AFS checklist (Robins et al. 1991). Mayden (1989) placed this species in the genus Erimystax but later agreed that it belongs in Cyprinella (see Jenkins and Burkhead 1994). Page and Burr (1991, 2011), Etnier and Starnes (1993), and Jenkins and Burkhead (1994) included it in Cyprinella . Broughton and Gold (2000) examined mtDNA variation in Cyprinella and found that this species fell outside of a monophyletic Cyprinella as sister to Hybopsis winchelli. Nelson et al. (2004) followed Mayden et al. (1992) in placing this species in the genus Erimonax. (NatureServe, 2015). The spotfin chub seems to be a phyletic key species linking two large, complex groups of eastern American minnows--shiners (Notropis) and certain non-nestbuilding barbeled "chubs" (Hybopsis) (USFWS, 1983).

Historical Range

This once widespread species was historically known from 24 streams in 12 tributaries of the upper and middle Tennessee River system, in Alabama (extirpated; Boschung and Mayden 2004), Georgia (extirpated), North Carolina (Menhinick 1991), Tennessee (Etnier and Starnes 1993), and Virginia (Jenkins and Burkhead 1994). (NatureServe, 2015)

Current Range

The species now survives in only five isolated tributary systems: Duck River (B. M. Burr, pers. comm., cited by Boschung and Mayden 2004) and very small segment of the Buffalo River, Lewis County, Tennessee; Emory River system (including the Obed River, Clear Creek, and Daddys Creek), Morgan, Cumberland, and Fentess counties, Tennessee; North Fork Holston River, Hawkins and Sullivan counties, Tennessee, and Scott and Washington counties, Virginia; South Fork Holston River (specifically the Middle Fork; isolated by impoundments), Washington County, Virginia; and Little Tennessee River, Macon and Swain counties, North Carolina (USFWS 1983, 2002; Jenkins and Burkhead 1994).Conservation Fisheries, Inc. (CFI), attempted to reintroduce the species into Abrams Creek, but the species did not become established (P. Rakes, pers. comm., 2014). USFWS (2005) announced its intention to reintroduce the spotfin chub in Shoal Creek, Lauderdale County, Alabama, and Lawrence County, Tennessee, as a nonessential experimental population (species was collected in Shoal Creek in 1889). As of 2014, the status of the reintroduced population in Shoal Creek was uncertain (P. Rakes, pers. comm., 2014). USFWS (2002) announced its intention to establish a nonessential experimental population in the Tellico River, upstream from Tellico Reservoir, Monroe County, Tennessee. As of 2014, the species appeared to be successfully reestablished in the Tellico River (P. Rakes, pers. comm., 2014).USFWS (2007) announced plans to reintroduce E. monachus into probable historical habitat in the free-flowing reach of the French Broad River from below Douglas Dam to its confluence with the Holston River, Knox County, Tennessee, and in the free-flowing reach of the Holston River from below Cherokee Dam to its confluence with the French Broad River. The geographic boundaries of this nonessential experimental population would extend from the base of Douglas Dam (river kilometer 51.7) down the French Broad River, Knox and Sevier Counties, Tennessee, to its confluence with the Holston River and then up the Holston River, Knox, Grainger, and Jefferson counties, Tennessee, to the base of Cherokee Dam (river kilometer 83.7 km) and would include the lower 8 kilometers of all tributaries that enter these river reaches.As of 2014, CFI was conducitng spotfin chub status surveys in the Nork Fork and Middle Fork Holston rivers (P. Rakes, pers. comm., 2014). (NatureServe, 2015)

Critical Habitat Designated

Yes; 9/22/1977.

Legal Description

On September 22, 1977, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Erimonax monachus (Spotfin chub) under the Endangered Species Act of 1973, as amended (42 FR 45526 - 45530). A Correction and Augmentation Final Rule was issued on September 22, 1977 (42 FR 47840-47845). The critical habitat designation includes four critical habitat units (CHUs), in North Carolina, Tennessee and Virginia.
The critical habitat designation for Erimonax monachus includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Erimonax monachus.

Critical Habitat Designation

The critical habitat designation for Erimonax monachus includes four CHUs, in Macon and Swain counties, North Carolina; Cumberland, Fentress, Morgan, Hawkins and Sullivan counties, Tennessee and Scott and Washington Counties, Virginia (47 FR 47840-47845).

Unit 1—North Carolina, Macon and Swain Counties. Little Tennessee River, main channel from the backwaters of Fontana Lake upstream to the North Carolina-Georgia State line.

Unit 2—Tennessee. Cumberland, Fentress, and Morgan Counties. Emory and Obed Rivers and Clear and Daddys Creek in Morgan County. Clear Creek in Fentress County. Obed River upstream to U.S. Interstate Highway 40, Clear Creek upstream to U.S. Interstate Highway 40 and Daddys Creek upstream to U.S. Highway 127 in Cumberland County.

Unit 3—Tennessee. Hawkins and Sullivan Counties. North Fork Holston, main channel upstream from junction with South Fork Holston River to the Tennessee-Virginia State line.

Unit 4—Virginia. Scott and Washington Counties. North Fork Holston River, main channel from the Virginia-Tennessee State line upstream through Scott and Washington Counties.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Erimonax monachus critical habitat do not appear to be listed in this document (47 FR 47840-47845):

Life History

Feeding Narrative

Adult: The species is an insectivore with a diurnal feeding strategy using both sight and taste (USFWS, 1983). Its food source consists primarily of immature aquatic insects, "largely small" chironomids and simuliids, plus some mayfly nymphs and caddisfly larvae. Prey items are distributed at the benthic level of creeks and rivers. It is inferred that interspecific competition is likely (NatureServe, 2015).

Reproduction Narrative

Adult: The species is oviparous. Maturity is reached at 2 years (though some may spawn at 1 year), with a maximum lifespan of 3 years. Spawning possibly begins in late May and extends into July or August. Nuptial adults have been taken from mid-May to mid-August. Females probably produce several clutches of eggs in a single season. Eggs are laid in stone cracks, crevices, or in the narrow interface of two touching rocks. Breeding sites exist in moderate currents of shallow portions of runs, in areas strewn with unsilted rubble and boulders (NatureServe, 2015).

Dependency on Other Individuals or Species for Habitat

Adult: At least partly dependent upon ingress of chubs (USFWS, 1983)

Habitat Narrative

Adult: The species lives in streams and tributary systems. It is at least partly dependent on the ingress of chubs (USFWS, 1983). Stream types include large creeks or medium-sized rivers of moderate benthic gradient. Cool and warm, clear waters are considered a key resource needed for habitat (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Moderate (inferred from USFWS, 1983)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigrant (NatureServe, 2015)

Dispersal

Adult: Low (inferred from USFWS, 1983)

Dispersal/Migration Narrative

Adult: The species is non-migrant. It is inferred to have moderate mobility and low dispersal, based on its taxonomy and its relatively non-migrant behavior (USFWS, 1983).

Population Information and Trends

Population Trends:

Decline of 50-70% (NatureServe, 2015)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

Historical range included 12 Tennessee River tributaries; current distribution includes only 5 of those, and the species "tenuously" persists in two of them (Jenkins and Burkhead 1994). Jenkins and Burkhead (1994) indicated possible recovery and expansion of area of occupancy with pollution abatement in part of the North Fork Holston River in Virginia. Decline of 50-70% Total adult population size is unknown. This species is generally rare or uncommon and usually sharply localized in distribution (Burkhead and Jenkins 1991), though it is not rare in the Emory River system. Small, localized populations are restricted to a small part of any riffle-run sequence (Jenkins and Burkhead 1994). Survey technique may affect apparent abundance; this fish is not easy to capture with a seine (Etnier and Starnes 1993). Jenkins and Burkhead (1984, 1994) and Boschung and Mayden (2004) indicated current occupancy of 10 streams, each of which could be regarded as a distinct occurrence, subpopulation, or location. (NatureServe, 2015)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Threats to the spotfin chub and its habitat include agriculture (both crop and livestock) amd forestry operations, mining activities, highway and road construction, residential and industrial developments, and other construction and land-clearing activities that do not adequately control soil erosion and storm-water run-off contribute excessive amounts of silt, pesticides, fertilizers, heavy metals, and other pollutants. The run-off of storm water from cleared areas, roads, rooftops, parking lots, and other developed areas, which is often ditched or piped directly into streams, not only results in stream pollution but also results in increased water volume and velocity during heavy rains. The high volume and velocity cause channel and stream-bank scouring that leads to the degradation and elimination of fish habitat. Construction and land-clearing operations are particularly detrimental when they result in the alteration of flood plains or the removal of forested stream buffers that ordinarily would help maintain water quality and the stability of stream banks and channels by absorbing, filtering, and slowly releasing rainwater. When storm water run-off increases from land-clearing activities, less water is absorbed to recharge ground water levels. Therefore, flows during dry months can decrease and adversely affect mussels and other aquatic organisms (USFWS, 2011).

Recovery

Reclassification Criteria:

Not available

Delisting Criteria:

Not available

Recovery Actions:

- Preserve populations and presently used habitat of the spotfin chub (USFWS, 1983).
- Determine the feasibility of reestablishing the species back into its historic range and introduce where feasible and necessary to meet recovery objectives (USFWS, 1983).
- Conduct life history studies not covered above, i.e., age and growth, reproductive biology, longevity, natural mortality factors, and population dynamics (USFWS, 1983).
- Investigate the necessity for habitat improvement and, if feasible and necessary to meet recovery, develop techniques and sites for habitat improvement and implement (USFWS, 1983).
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations (USFWS, 1983).
- Assess overall success of recovery program and recommend action (delist, continued protection, implement new measures, other studies, etc.) (USFWS, 1983).
- Recommendations for future actions: Priority Actions. 1. A species status assessment should be prepared to evaluate the species status under the ESA and help inform recovery planning prior to the development of the next 5-year review. 2. Continue the 10-year monitoring program. 3. Initiate more 10-year monitoring programs on other creeks. 4. Ascertain lethal and sublethal temperature and do thresholds. 5. Study the effects of dam releases. 6. Survey streams where the species is considered extirpated. 7. Conduct a population genetics study. 8. Reintroduce the species in suitable streams within its historical range. 9. Continue to refine propagation techniques. 10. Determine degree of threat to extant pops. 11. Conduct a rangewide taxonomic distinction. 12. Continue to work with TVA (USFWS, 2014).

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SPECIES ACCOUNT: *Erimystax cahni* (Slender chub)

Species Taxonomic and Listing Information

Listing Status: Experimental Population, Non-Essential; 10/11/1977, 10/15/2007; Southeast Region (R4) (USFWS, 2016)

Physical Description

The slender chub is 8 cm in length [NatureServe 2015]

Taxonomy

The slender chub is a schooling minnow [NatureServe 2015]. While the formal listing rule and recovery plans identify the listed taxon as Hybopsis cahni, the listed species is presently recognized by scientists and ichthyologists by the scientific name Erimystax cahni [USFWS 2014].

Historical Range

The historical range of the slender chub included the Holston River (a single specimen) and Clinch River (15 total specimens at two localities) in areas presently inundated by Tennessee Valley Authority (TVA) Cherokee and Norris dams, respectively (Table 1). Since the 1960’s, the species has only been collected or observed at four separate localities encompassing 7.7 stream kilometers (km) in the Clinch River and six localities encompassing 84.2 km in the Powell River (Table 1). As noted by Burkhead and Jenkins (1982) the slender chub was believed extant only in the Clinch and Powell rivers at the time of listing [USFWS 2014].

Current Range

The slender chub is endemic to the upper Tennessee River in Tennessee and Virginia. The species is known to exist at five sites on the Powell River and four on the Clinch River [USFWS 1983].

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 10/11/1977.

Legal Description

On September 9, 1977, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Hybopsis cahni (Slender chub) under the Endangered Species Act of 1973, as amended (42 FR 45526 - 45530). A Correction and Augmentation Final Rule was issued on September 22, 1977 (42 FR 47840-47845). The critical habitat designation includes two critical habitat units (CHUs), in Tennessee and Virginia .

The critical habitat designation for Hybopsis cahni includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Hybopsis cahni.

Critical Habitat Designation

The critical habitat designation for Hybopsis cahni includes two CHUs, in Clairborne and Hancock Counties, Tennessee and Lee and Scott Counties, Virginia (47 FR 47840-47845).

Unit 1—Tennessee. Claiborne and Hancock Counties. Powell River, main channel from backwaters of Norris Lake upstream to the Tennessee-Virginia State line. Clinch River, main channel from backwaters of Norris Lake upstream to the Tennessee-Virginia State line.

Unit 2—Virginia. Lee and Scott Counties. Powell River, main channel from the Tennessee Virginia State line upstream through Lee County. Va. Clinch River, main channel from the Tennessee-Virginia State line upstream through Scott County, Va.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Hybopsis cahni critical habitat do not appear to be listed in this document (47 FR 47840-47845):

Life History

Feeding Narrative

Juvenile: The slender chub is a generalist invertivore that feeds within the stream, primarily on benthic organisms including immature aquatic insects, small bivalves, and snails [NatureServe 2015; USFWS 1983].

Adult: The slender chub is a generalist invertivore that feeds within the stream, primarily on benthic organisms including immature aquatic insects, small bivalves, and snails [NatureServe 2015; USFWS 1983].

Reproduction Narrative

Juvenile: The slender chub engages in demersal spawning, which occurs in late April and early May. Individuals live up to 2 years and a few months [NatureServe 2015]. Fecundity is relatively low. The species might be introgressively hybridizing with the closely related blotched and/or streamline chubs [USFWS 2014].

Adult: The slender chub engages in demersal spawning, which occurs in late April and early May. Individuals live up to 2 years and a few months [NatureServe 2015]. Fecundity is relatively low. The species might be introgressively hybridizing with the closely related blotched and/or streamline chubs [USFWS 2014].

Habitat Narrative

Juvenile: The slender chub is a freshwater fish, inhabiting moderately sized rivers with riffle areas and of moderate gradient [NatureServe 2015]. The species prefers clean swept, relatively loose pea-sized gravel in moderate runs where water depth is 0.2 to 0.4 meters [USFWS 1983].

Adult: The slender chub is a freshwater fish, inhabiting moderately sized rivers with riffle areas and of moderate gradient [NatureServe 2015]. The species prefers clean swept, relatively loose pea-sized gravel in moderate runs where water depth is 0.2 to 0.4 meters [USFWS 1983].

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Non-migrant [inferred from USFWS 1983]

Adult: Non-migrant [inferred from USFWS 1983]

Dispersal

Juvenile: Unavailable [NatureServe 2015]

Adult: Unavailable [NatureServe 2015]

Immigration/Emigration

Juvenile: No [inferred from USFWS 1983]

Adult: No [inferred from USFWS 1983]

Dispersal/Migration Narrative

Juvenile: The slender chub is non-migrant and does not emigrate. Information pertaining to dispersal is not available [USFWS 1983].

Adult: The slender chub is non-migrant and does not emigrate. Information pertaining to dispersal is not available [USFWS 1983].

Population Information and Trends

Population Trends:

Decreasing [inferred from USFWS 2014]

Population Growth Rate:

Unknown [inferred from USFWS 2014]

Minimum Viable Population Size:

Unknown [inferred from USFWS 2014]

Resistance to Disease:

Unknown [inferred from USFWS 2014]

Adaptability:

Low [inferred from USFWS 2014]

Additional Population-level Information:

Species might be introgressively hybridizing with the closely related blotched and/or streamline chubs [USFWS 2014].

Population Narrative:

The slender chub population is presumed to be decreasing and suspected of potentially being extinct based on researchers' inability to find the fish in recent years. Hence it is inferred that resiliency, representation, redundancy, and adaptability are all low. Population growth rate, minimum viable population, and resistance to disease are not known. well, when you have dis [USFWS 2014]. No individuals have been collected for over 20 years, small populations may still exist in the Powell River and Clinch River (USFWS, 2021)

Threats and Stressors

Stressor: Siltation [USFWS 1983]
Exposure:
Response:
Consequence:
Narrative: Some increases in silt in the form of coal fines have been observed in the Clinch River since 1975 (Ahlstedt, 1982 personal communication) and if this problem increases, further impacts on the species and its habitat can be expected [USFWS 1983].

Stressor: Industrial effluent resulting from reservoir development [USFWS 1983]
Exposure:
Response:
Consequence:
Narrative: The river above the Cherokee Reservoir is impacted by industrial effluent from Kingsport, Tennessee (Higgins, 1978) [USFWS 1983].

Stressor: Cold water releases [USFWS 1983]
Exposure:
Response:
Consequence:
Narrative: The habitat below the (Cherokee Reservoir) is affected by cold water releases [USFWS 1983].

Stressor: Toxic chemical spills [USFWS 1983]
Exposure:
Response:
Consequence:
Narrative: The ecosystem was stressed by two toxic chemical spills: one in 1967 that resulted in a kill extending to 266.4 rkm. A sulphuric acid spill in 1970 killed fish for 22 rkm [USFWS 1983].

Recovery

Reclassification Criteria:
Reclassification criteria not specified.
Reclassification criteria not specified.
Reclassification criteria not specified.
Reclassification criteria not specified.
Reclassification criteria not specified.
Reclassification criteria not specified.

Delisting Criteria:
Through protection of existing populations and/or by introductions and/or discovery of new populations, there exist viable populations in the Powell River, Clinch River and Holston River

[USFWS 1983].

Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no increase in coal or other energy-related impacts exist in the Clinch River [USFWS 1983].

The species and its habitat in all three rivers are protected from foreseeable human related and natural threats that may adversely affect essential habitat or survival of any of the populations [USFWS 1983].

Recovery Actions:

- Preserve populations and currently occupied habitat of the slender chub [USFWS 1983].
- Determine the feasibility of reestablishing the species in the Holston River and introduce where feasible and necessary to meet recovery objectives [USFWS 1983].
- Conduct life history studies not covered under section 1.2.2 above, i.e., age and growth, reproductive biology, longevity, natural mortality factors, and population dynamics on a need to know basis [USFWS 1983].
- Investigate the necessity for habitat improvement and, if feasible and necessary to meet recovery, develop techniques and sites for habitat improvements and implement [USFWS 1983].
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations [USFWS 1983].
- Annually assess overall success of recovery program and recommend action (adjustment in recovery objectives, delist, continued protection, implement new measures, other studies, etc.) [USFWS 1983].
- None developed; see Recovery Actions

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SPECIES ACCOUNT: *Etheostoma boschungi* (Slackwater darter)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/11/1977; Southeast Region (R4) (USFWS, 2015)

Physical Description

A two-inch fish (NatureServe, 2015). The slackwater darter has two anal spines, a soft dorsal fin usually with 11 or 12 rays, and three prominent dorsal saddles (Wall and Williams, 1974; Williams and Robinson, 1980) (USFWS, 1984).

Taxonomy

See Wall and Williams (1974) for original description. Placed in new subgenus Ozarka by Williams and Robison (1980). (NatureServe, 2015)

Historical Range

This species is known from five tributary streams to the south bend of the Tennessee River: Buffalo River (Lawrence county, TN), Shoal Creek (Lawrence county, TN), Flint River (Madison county, AL), Swan Creek (Limestone county, AL), Cypress Creek watershed (Wayne county, TN; Tennessee and Lauderdale county, AL) (USFWS, 1984).

Current Range

Range includes the middle Tennessee River drainage, from the Flint River, northern Alabama, to the Buffalo River, south-central Tennessee (Page and Burr 2011); headwaters of Buffalo River and upper Shoal Creek in Lawrence County, Tennessee; several tributaries of the south bend of the Tennessee River, including Cypress Creek system in Alabama and Tennessee, Swan and Limestone creeks, and West Fork, Brier Fork and Copeland Branch of the Flint River system in Alabama and Tennessee (Etnier and Starnes 1993, Mettee et al. 1996, Boschung and Mayden 2004, USFWS 2008). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/22/1977.

Legal Description

On September 9, 1977, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Etheostoma boschungi (Slackwater darter) under the Endangered Species Act of 1973, as amended (42 FR 45526 - 45530). A Correction and Augmentation Final Rule was issued on September 22, 1977 (42 FR 47840-47845). The critical habitat designation includes three critical habitat units (CHUs), in Alabama and Tennessee .
The critical habitat designation for Etheostoma boschungi includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Etheostoma boschungi.

Critical Habitat Designation

The critical habitat designation for Etheostoma boschungi includes three CHUs, in Lauderdale County, Alabama and Lawrence and Wayne Counties, Tennessee (47 FR 47840-47845).

Unit 1—Alabama. Lauderdale County. All permanent and intermittent streams with flowing water from December to June tributary to Cypress Creek and its tributaries upstream from the junction of Burcham Creek, including Burcham Creek, excluding Threet Creek and its tributaries.

Unit 2—Tennessee. Wayne County. All permanent and intermittent streams with flowing water from December to June tributary to Cypress and Middle Cypress Creek drainage.

Unit 3—Tennessee. Lauderdale County. Buffalo River and all its tributaries in Lawrence County, Tennessee.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Etheostoma boschungi critical habitat do not appear to be listed in this document (47 FR 47840-47845):

Life History

Feeding Narrative

Adult: Eats mainly larval insects, amphipods, isopods, and limpets (Lee et al. 1980, Etnier and Starnes 1993). Adults and immatures are invertivores (NatureServe, 2015). The initial growth period is rapid; specimens in early April are from 10 to 12 mm S.L., and by early June they have doubled in length (USFWS, 1994).

Reproduction Narrative

Adult: Spawns late January to March or early April at temperatures at or above 14 C (Lee et al. 1980, Mettee et al. 1996). Males defend egg-laden clumps of plants (Matthews and Moseley 1990). Adults and young apparently move from spawning areas to streams in April (Etnier and Starnes 1993). Spawning occurs in very shallow seepage water in fields and open woods; individuals are carried into these areas after heavy spring rains. Typical breeding habitat is characterized by the presence of Juncus and Eleocharis in clear, moving seepage or spring water; dry in summer. Eggs are attached to Juncus or Eleocharis. Some populations may not require this type of habitat for breeding (see USFWS 2008). Sexually mature at age 2, maximum lifespan about 3 years (Etnier and Starnes 1993) (NatureServe, 2015). Three specimens averaged 320 ripe eggs, however another had approximately 1000 eggs in some stage of development (USFWS, 1994).

Geographic or Habitat Restraints or Barriers

Adult: Dams, high waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear, clumped (USFWS, 1994; see Fig. 4)

Environmental Specificity

Adult: Narrow (inferred from NatureServe, 2015)

Habitat Narrative

Adult: This darter typically inhabits gravel-bottomed pools in sluggish areas of creeks and small rivers that generally are not more than 12 meters wide and 2 meters deep; often it occurs in slow water beneath undercut banks (especially in wide streams) or in accumulations of old leaf litter or detritus (Lee et al. 1980, Etnier and Starnes 1993, Boschung and Mayden 2004, Page and Burr 2011). It is associated with dense filamentous algae in the upper Buffalo River (Etnier and Starnes 1993). It typically avoids riffle and rapids but will traverse swifter streams during migrations to breeding habitat (Lee et al. 1980). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Moderate (inferred from NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Seasonal movements (NatureServe, 2015)

Dispersal

Adult: Moderate (inferred from NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Migrates locally between spawning and adjacent nonspawning habitats (Ono et al. 1983, Mettee et al. 1996) (NatureServe, 2015).

Population Information and Trends

Population Trends:

Declining (NatureServe, 2015)

Species Trends:

Declining (USFWS, 2008)

Number of Populations:

5 (USFWS, 2024)

Population Size:

2500 - 10,000 individuals (NatureServe, 2015)

Additional Population-level Information:

The slackwater darter occurs in five systems of the middle Tennessee River: Cypress Creek watershed (Lauderdale Co., AL and Wayne Co., TN); Swan Creek watershed (Limestone Co., AL); Flint River watershed (Madison Co., AL and Lincoln Co., TN); Shoal Creek watershed (Lawrence Co., TN; and Buffalo River watershed (Lawrence Co., TN). Survey efforts in 2022 by the Service and Alabama Department of Environmental Management collected slackwater darters at three locations, two sites in Alabama and one in Tennessee in the Cypress Creek population. The Alabama sites in Limestone County and Lauderdale County are currently the only confirmed spawning locations of this species in the state (USFWS, 2022).

Population Narrative:

The currently disjunct populations reflect extirpations within a formerly continuous and more ubiquitous distribution (Boschung and Mayden 2004). Five of 31 historical sites have been lost or degraded to a point that they no longer provide suitable habitat (see USFWS 2008). As of the 1970s, the largest population was in Cypress Creek watershed, with an estimated population of 2400-3600 (Boschung 1976); other populations comprise only a few hundred individuals. The species is regarded as rare and sporadically distributed (USFWS 2008). Boschung and Mayden (2004) mapped 15 collection sites in Alabama; Etnier and Starnes (1993) mapped 5 collection sites in Tennessee. These represent several (more than 5) distinct occurrences (subpopulations). Etnier and Starnes (1993) stated that "only about 10 populations are known." USFWS (2008) reported that this species "is currently known or has been known" from six tributary streams; this comprise 31 historical sites. (NatureServe, 2015)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: The primary threat is habitat degradation resulting in a decline in water quality; sedimentation is believed to be the main cause for the decline of slackwater darter populations. Sediment sources within the current range include activities that disturb the land surface, bankside or stream bottom. Urbanization impacts of the surrounding habitat within the watershed includes construction and land alteration, bridge and road construction, lack of effective storm water management, maintenance of mentioned activities, ditching to drain areas with shallow groundwater and, in general, changes in stream hydrology and geomorphology. The mentioned are also examples of point and non point source sediment sources. The amount and impact of sedimentation on the slackwater darter's habitat can be locally con-elated with land use practices such as construction, urbanization, road maintenance, and soil type. Impacts from cattle on spawning habitat and banks sides, stream bottoms, and streamside vegetation have been noted (USFWS, 2008).

Recovery

Reclassification Criteria:
Recovery Priority Number: 8 (USFWS, 2024)

Delisting Criteria:

1. Establishment and protection of one or more specific habitat areas in at least three different tributaries to the Tennessee River System where the slackwater darter is known to occur with specific spawning areas to be protected by purchase or cooperative agreement (USFWS, 1994).

2. Data indicate that the populations are stable or increasing in number (USFWS, 1994).

3. Water quality and ecological data to indicate that the environment is suitable and stable or improving (USFWS, 1994).

Recovery Actions:

- Assess current status of slackwater darter and its habitats (USFWS, 1994).
- Conduct life history studies (USFWS, 1994).
- Locate breeding habitats for populations in Buffalo River, Flint River, Shoal Creek, and Swan Creek (USFWS, 1994).
- Protect slackwater darter essential habitat (USFWS, 1994).
- A monitoring plan should be developed and implemented for the slackwater darter (USFWS, 2008).
- Current and historical habitats for this species should be assessed, prioritized, and monitored (USFWS, 2008).
- Habitat, including spawning and non-spawning, such as seasonal seepages and springs should be inventoried and protected through cooperative agreement, conservation easement, fee title purchase or other means to guarantee safeguards to the water quality, especially turbidity, water quantity, geomorphology, hydrology and other aspects of the habitat and natural history of the species. Specifically, the Dodd site in Wayne County, Tennessee, is very important and should be protected through purchase or conservation easement (USFWS, 2008).
- Landowners need to be made aware of the importance of spring seepages, spring runs and "slack water" (USFWS, 2008).
- Establish a catalog of potential restoration sites and lands (USFWS, 2008).
- Existing regulations and land management laws should be enforced (USFWS, 2008).
- Propagation studies and efforts should continue (USFWS, 2008).
- All other recovery tasks should be implemented (USFWS, 2008).
- Revise the Recovery Plan to reflect new information and threat concerns (USFWS, 2008).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES A detailed discussion of recovery actions and criteria are presented in the Recovery Plan (Service 1984). During the course of this status review new and/or targeted potential recovery activities were identified and are included below. Recovery Activities • Establishment and protection of one or more specific habitat areas (to be determined based on data from Tasks 1.1, 2.1, and 3) in at least three different tributaries to the Tennessee River System where the slackwater darter is known to occur with specific spawning areas to be protected by purchase or cooperative agreement. Monitoring and Research Activities • Population monitoring should be conducted to assess the response of the slackwater darter to continued threats, determine the current population size, and determine location occurrences of this species. o Data to indicate population condition. o Water quality and ecological data to indicate habitat suitability. o Conduct winter and early spring census near and in known breeding habitats (Task 1.1 in Recovery Plan). • Study assembly, migration and migration routes (Task 2.1 in Recovery Plan). • Locate breeding habitats for populations in the Buffalo River, Flint River, Shoal Creek, and Swan Creek (Task 3 in Recovery Plan). • Continue the use of eDNA to determine potential presence of the slackwater darter in known and potentially new sites. Follow up fish surveys should be performed to determine occupancy. • Perform assessments at road/stream crossings in the species’ range to determine if instream barriers exist that hinder slackwater darter migration. Where feasible, make passage improvements at priority road/stream crossings (USFWS, 2024).

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SPECIES ACCOUNT: *Etheostoma chermocki* (Vermilion darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/28/2001; Southeast Region (R4) (USFWS, 2015)

Physical Description

The vermilion darter is a medium-sized darter reaching about 7.1 centimeters (2.8 inches) total length (length from tip of snout to the longest portion of tail fin) (Boschung et al., 1992; Suttkus and Bailey, 1993) (USFWS, 1997).

Taxonomy

Formerly included in a group of undescribed fishes collectively known as "Black Warrior snubnose darter." Etheostoma chermocki comprises part of the entity referred to by Mettee et al. (1989) as Etheostoma sp. B. See Boschung et al. (1992). (NatureServe, 2015)

Historical Range

This species is known only from the Turkey Creek drainage, a tributary to Locust Fork, Black Warrior River system, Jefferson County, Alabama; it is known from 11.6 km of the mainstem Turkey Creek and the lowermost reaches (0.8 km) of Dry Creek and Beaver Creek where they intersect Turkey Creek (Boschung et al. 1992; Mettee et al. 1996; USFWS 1999, 2000, 2001) (NatureServe, 2015).

Current Range

The current range of the vermilion darter is slightly reduced from the historic range. The current range of the vermilion darter is restricted to localized sites within the upper mainstem reach of Turkey Creek and four tributaries in Pinson, Jefferson County, Alabama (Boschung and Mayden 2004) (USFWS, 2011).

Distinct Population Segments Defined

No (USFWS, 2015)

Critical Habitat Designated

Yes; 12/7/2010.

Legal Description

On December 7, 2010, the U.S. Fish and Wildlife Service (Service), designated critical habitat for the vermilion darter (Etheostoma chermocki) under the Endangered Species Act of 1973, as amended (75 FR 75913 - 75931). The Service designated as critical habitat approximately 21.0 kilometers (km) (13.0 miles (mi)) of stream in 5 units within the Turkey Creek watershed in Jefferson County, AL.

Critical Habitat Designation

The critical habitat designation for Etheostoma chermocki includes five units totaling approximately 21.2 stream km (13.1 stream mi) in Jefferson County, Alabama. The units are Turkey Creek, Dry Branch, Beaver Creek, Dry Creek, and Unnamed Tributary to Beaver Creek.

Unit 1: Turkey Creek, Jefferson County, Alabama: Unit 1 includes 15.2 km (9.4 mi) in Turkey Creek from Shadow Lake Dam downstream to the Section 13/14 (T15S, R2W) line, as taken from the U.S. Geological Survey 7.5-minute topographical map (Pinson quadrangle). Approximately 14.9 km (9.2 mi), or 98 percent of this area is privately owned. The remaining 0.3 km (0.2 mi), or 2 percent is publicly owned by the City of Pinson or Jefferson County in the form of bridge crossings and road easements. Turkey Creek supports the most abundant and robust populations of the vermilion darter in the watershed. Populations of vermilion darters are small and isolated within specific habitat sites of Turkey Creek from Shadow Lake dam downstream to the old strip mine pools (13/14 S T15S R2W section line, as taken from the U.S. Geological Survey 7.5-minute topographical map (Pinson quadrangle)). The Service considers the entire reach of Turkey Creek that composes Unit 1 to be occupied. One of the three known spawning sites for the species (Stiles, pers. comm. 1999) is located within the confluence of Turkey Creek and Tapawingo Spring run (Primary Constituent Element 4). In addition, Turkey Creek provides the most darter habitat for the vermilion darters with an abundance of pools, riffles, and runs (Primary Constituent Element 1). These geomorphic structures provide the species with spawning, foraging, and resting areas (Primary Constituent Elements 1 and 4), along with good water quality, quantity, and flow, which support the normal life stages and behavior of the vermilion darter and the species' prey sources (Primary Constituent Elements 2 and 3). There are five impoundments in Turkey Creek (Blanco and Mayden 1999, pp. 5–6, 36, 63) limiting the connectivity of the range and expansion of the species into other units and posing a risk of extinction to the species due to changes in flow regime, habitat, water quality, water quantity, and stochastic events such as drought. These impoundments accumulate nutrients and undesirable fish species that could propose threats to vermilion darters and the species' habitat. Other threats to the vermilion darter and its habitat in Turkey Creek which may require special management and protection of primary constituent elements include the potential of: urbanization activities (such as channel modification for flood control, inadequate stormwater management, or gravel extraction) that could result in increased bank erosion; significant changes in the existing flow regime due to water diversion or water withdrawal; significant alteration of water quality; and significant changes in stream bed material composition and quality as a result of construction projects and maintenance activities; offroad vehicle use; sewer, gas, and water easements; bridge construction; culvert and pipe installation; and other watershed and floodplain disturbances that release sediments or nutrients into the water.

Unit 2: Dry Branch, Jefferson County, Alabama: Unit 2 includes 0.7 km (0.4 mi) of Dry Branch from the bridge at Glenbrook Road downstream to the confluence with Beaver Creek. Most of the 0.7 km (0.4 mi) or close to 100 percent of this area is privately owned. Less than 1 percent of the area is publicly owned by the City of Pinson or Jefferson County in the form of bridge crossings and road easements. Dry Branch provides supplemental water quantity to Turkey Creek proper (Unit 1) and provides connectivity to additional bottom substrate habitat and possible spawning sites (Primary Constituent Elements 1, 3, and 4). One of the three known spawning sites for the species is located within the confluence of this reach (Primary Constituent Element 1 and 4) and Beaver Creek (Stiles, pers. comm. 2009). Threats to the vermilion darter and its habitat at Dry Branch which may require special management and protection of Primary Constituent Elements 1, 3, and 4 include the potential of: urbanization activities (such as channel modification for flood control, inadequate stormwater management, construction of impoundments, and gravel extraction) that could result in increased bank erosion; significant changes in the existing flow regime due to construction of impoundments, water diversion, or water withdrawal; significant alteration of water quality; and significant changes in stream bed material composition and quality as a result of construction projects and maintenance activities; offroad vehicle use; sewer, gas, and water easements; bridge construction; culvert and pipe installation; and other watershed and floodplain disturbances that release sediments or nutrients into the water.

Unit 3: Beaver Creek, Jefferson County, Alabama: Unit 3 includes 1.0 km (0.6 mi) of Beaver Creek from the confluence with the unnamed tributary to Beaver Creek and Dry Branch downstream to the confluence with Turkey Creek. Almost 0.9 km (0.6 mi), or 94 percent of this area, is privately owned. The remaining 0.1 km (under 0.1 mi), or 6 percent is publicly owned by the City of Pinson or Jefferson County in the form of bridge crossings and road easements. Beaver Creek supports populations of vermilion darters, and provides supplemental water quantity to Turkey Creek proper (Primary Constituent Elements 1 and 2). The reach also contains adequate bottom substrate for vermilion darters to use in spawning, foraging, and other life processes (Primary Constituent Element 4). Beaver Creek makes available additional habitat and spawning sites, and offers connectivity with other vermilion darter populations within Turkey Creek, Dry Branch, and the unnamed tributary to Beaver Creek (Primary Constituent Elements 1 and 4). Threats to the vermilion darter and its habitat at Beaver Creek which may require special management of Primary Constituent Elements 1, 2, and 4 include the potential of: urbanization activities (such as channel modification for flood control, construction of impoundments, gravel extraction) that could result in increased bank erosion; significant changes in the existing flow regime due to inadequate stormwater management, water diversion, or water withdrawal; significant alteration of water quality; and significant changes in stream bed material composition and quality as a result of construction projects and maintenance activities; off-road vehicle use; sewer, gas, and water easements; bridge construction; culvert and pipe installation; and other watershed and floodplain disturbances that release sediments or nutrients into the water.

Unit 4: Dry Creek, Jefferson County, Alabama: Unit 4 includes 0.6 km (0.4 mi) of Dry Creek from Innsbrook Road downstream to the confluence with Turkey Creek. One hundred percent of this area, is privately owned. Dry Creek supports populations of vermilion darters and provides supplemental water quantity to Turkey Creek proper (Primary Constituent Elements 1 and 2). The reach also contains adequate bottom substrate for vermilion darters to use in spawning, foraging, and other life processes (Primary Constituent Element 4). Dry Creek makes available additional habitat and spawning sites, and offers connectivity with vermilion darter populations in Turkey Creek (Primary Constituent Element 1). There are two impoundments in Dry Creek (Blanco and Mayden 1999, pp. 56, 62) which limit the range and expansion of the species within the unit and increases the risk of extinction due to changes in flow regime, habitat or water quality, water quantity, and stochastic events such as drought. These impoundments amass nutrients and undesirable fish species that could propose threats to vermilion darters and to its habitat. Threats that may require special management and protection of primary constituent elements include: urbanization activities (such as channel modification for flood control and gravel extraction) that could result in increased bank erosion; significant changes in the existing flow regime due to inadequate stormwater management and impoundment construction, water diversion, or water withdrawal; significant alteration of water quality; and significant changes in stream bed material composition and quality as a result of construction projects and maintenance activities, off-road vehicle use, sewer, gas and water easements, bridge construction, culvert and pipe installation, and other watershed and floodplain disturbances that release sediments or nutrients into the water.

Unit 5: Unnamed Tributary to Beaver Creek, Jefferson County, Alabama: Unit 5 includes 3.7 km (2.3 mi) of the unnamed tributary of Beaver Creek from the Section 1/2 (T16S, R2W) line, as taken from the U.S. Geological Survey 7.5-minute topographical map (Pinson quadrangle), downstream to its confluence with Beaver Creek. Almost 3.3 km (2.1 mi), or 89 percent of this area, is privately owned. The remaining 0.4 km (0.2 mi), or 11 percent, is publicly owned by the City of Pinson or Jefferson County in the form of bridge crossings and road easements. The unnamed tributary to Beaver Creek supports populations of vermilion darters and provides supplemental water quantity to Turkey Creek proper (Primary Constituent Elements 1 and 2). The unnamed tributary to Beaver Creek has been intensely geomorphically changed by man over the last 100 years. The majority of this reach has been channelized for flood control, as it runs parallel to Highway 79. There are several bridge crossings, and the reach has a history of industrial uses along the bank. However, owing to the groundwater effluent that constantly supplies this reach with clean and flowing water (Primary Constituent Elements 2 and 3), the reach has been able to support significant aquatic vegetation and a population of vermilion darters at several locations. One of the three known spawning sites for the species is located within this reach (Primary Constituent Element 4) (Kuhajda, pers. comm. May 2007). The headwaters of the unnamed tributary to Beaver Creek is characterized by natural flows that are attributed to an abundance of spring groundwater discharges contributing adequate water quality, water quantity, and substrates (Primary Constituent Elements 1, 2, and 3). Increasing the connectivity of the vermilion darter populations (Primary Constituent Element 1) into the upper reaches of this tributary is an essential conservation requirement as it would expand the range and decrease the vulnerability of these populations to stochastic threats. Threats to the vermilion darter and its habitat which may require special management and protection of primary constituent elements are: urbanization activities (such as channel modification for flood control, and gravel extraction) that could result in increased bank erosion; significant changes in the existing flow regime due to inadequate stormwater management and impoundment construction, water diversion, or water withdrawal; significant alteration of water quality; and significant changes in stream bed material composition and quality as a result of construction projects and maintenance activities; off-road vehicle use; sewer, gas, and water easements; bridge construction; culvert and pipe installation; and other watershed and floodplain disturbances that release sediments or nutrients into the water.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the primary constituent elements of the physical and biological features essential to the conservation of the vermilion darter consist of four components:

(i) Geomorphically stable stream bottoms and banks (stable horizontal dimension and vertical profile) in order to maintain bottom features (riffles, runs, and pools) and transition zones between bottom features, to promote connectivity between spawning, foraging, and resting sites, and to maintain gene flow throughout the species range.

(ii) Instream flow regime with an average daily discharge over 50 cubic feet per second, inclusive of both surface runoff and groundwater sources (springs and seepages) and exclusive of flushing flows.

(iii) Water quality with temperature not exceeding 26.7 °C (80 °F), dissolved oxygen 6.0 milligrams or greater per liter, turbidity of an average monthly reading of 10 NTU and 15mg/l TSS (Nephelometric Turbidity Units; units used to measure sediment discharge; Total Suspended

Solids measured as mg/l of sediment in water) or less; and a specific conductance (ability of water to conduct an electric current, based on dissolved solids in the water) of no greater than 225 micro Siemens per centimeter at 26.7 °C (80 °F).

(iv) Stable bottom substrates consisting of fine gravel with coarse gravel or cobble, or bedrock with sand and gravel, with low amounts of fine sand and sediments within the interstitial spaces of the substrates along with adequate aquatic vegetation.

Special Management Considerations or Protections

Critical habitat does not include manmade structures existing on the effective date of this rule and not containing one or more of the primary constituent elements, such as buildings, bridges, aqueducts, airports, and roads, and the land on which such structures are located.

None of the final critical habitat units are presently under special management or protection provided by a legally operative plan or agreement for the conservation of the vermilion darter. Various activities in or adjacent to the critical habitat units described in this final rule may affect one or more of the physical and biological features. For example, features in the final critical habitat designation may require special management due to threats posed by the following activities or disturbances: urbanization activities and inadequate stormwater management (such as stream channel modification for flood control or gravel extraction) that could cause an increase in bank erosion; significant changes in the existing flow regime within the streams due to water diversion or withdrawal; significant alteration of water quality; significant alteration in the quantity of groundwater and alteration of spring discharge sites; significant changes in stream bed material composition and quality due to construction projects and maintenance activities; off-road vehicle use; sewer, gas, and water easements; bridge construction; culvert and pipe installation; stormwater management; and other watershed and floodplain disturbances that release sediments or nutrients into the water.

Life History

Feeding Narrative

Adult: Adults and immatures are invertivores (NatureServe, 2015). Khudamrongsawat et al. (2005) found that vermilion darters were generalist benthic insectivores consuming larval chironomids, tipulids, and hydropsychids. Microcrustaceans may also be consumed (Carney and Burr, 1989) (USFWS, 2007).

Reproduction Narrative

Adult: The only documented spawning habitat consists of a mixture of fine silt on small gravel interspersed with larger gravel, cobble, small boulders, aquatic vegetation, small sticks and limbs on the substrate and occasional filamentous algae (Stiles, pers. Comm. 2007). Blanchard and Stiles (2005) found that vermilion darters preferred spawning substrate of large pebble and small cobble. All rock surfaces must be clean for egg laying (Blanchard and Drennen, 2004). Khudamrongsawat et al. (2005) examines museum collections and found that the sex ratio was female biased 2:1; darters matured at the end of the first year of life; age classes were 0 - 3; reproduction occurred from March to June, mean clutch size was 65 oocytes (USFWS, 2007).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Habitat includes small to medium-sized (3-20 m wide), gravel-bottomed streams with pools of moderate current alternating with riffles of moderately swift current; substrate varies from coarse gravel, cobble, and small rubble in riffles to rock, sand, and silt in pools; this darter apparently favors swifter chutes where there is some vegetation such as watercress or pondweed (Boschung et al. 1992). Separation barriers include dams lacking a suitable fishway, high waterfalls, and upland habitat. (NatureServe, 2015).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015)

Population Information and Trends

Population Trends:

Stable (USFWS, 2019)

Species Trends:

Stable (USFWS, 2019)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

3,300 (NatureServe, 2015)

Population Narrative:

The current range is slightly reduced from the historical distribution due to fragmentation of sites and separation of populations; natural (waterfall) and anthropogenic (impoundments) dispersal barriers contribute to the separation and isolation of vermilion darter populations (USFWS 2011). A 71 percent decline of vermilion darters was noted between 1995 and 1998 within the species' known range in the Turkey Creek mainstem (USFWS 2011). Decline of 70-80% In the late 1990s, overall population size was estimated at 3,300 or less; effective population size was estimated at 1,174 individuals; data are limited, but no major change is known to have occurred since then (USFWS 2011). Cursory surveys conducted sporadically within the Turkey Creek mainstem and tributaries from 2004-2009 indicate that this species is sparsely and sporadically distributed (see USFWS 2011). One occurrence. (NatureServe, 2015).

The vermilion darter population in Turkey Creek and tributaries appears to be relatively stable as reflected in recent surveys coupled with slight range extensions (Kuhajda, pers. comm., 2017). In addition, conservation gains have been made within site-specific habitats of the vermilion darter due to acquisition of habitat by FWLT and restoration efforts in the Turkey Creek watershed. However, upstream areas within the watershed are of prime development interests for hill top removal for exclusive subdivision development. Routinely after each major storm event, significant amounts of sediment and gravel from these development sites enter the system, increasing the water's turbidity and changing the bottom substrate. Water quality degradation continues to be an issue throughout the Turkey Creek watershed, and poses the major threat. The new concern of EDCs' effect on the vermilion darter needs further study and monitoring. The protection of habitat from ongoing and new threats, in addition to long-term monitoring of populations, is needed to ensure this species' viability into the future; therefore, the vermilion darter continues to meet the definition of an endangered species under the Act. (USFWS, 2019)

Threats and Stressors

Stressor: Water quality degradation (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Currently, several subdivision developments have faltered under declining economic conditions. In doing so, large areas of hill tops have been denuded and left to erode (Drennen pers. obs. September 2009). Erosion from these areas is significant with turbidity levels changing from 10- 15 NTU to 100-150 NTU within a couple of hours of heavy rains (Drennen pers. obs. September 2009, Rogers pers. comm. September 2009). Non-point source pollution from land surface runoff can originate from virtually any land use activity and may be correlated with impervious surfaces and storm water runoff. Pollutants may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of subsurface and surface waters such that the habitat and food sources for species like the vermilion darter are negatively impacted. Construction and road maintenance activities associated with urban development typically involve earth-moving activities that increase sediment loads into nearby aquatic systems through storm water runoff during and after precipitation events. Excessive sediment and increased turbidity can make the habitat of vermilion darters and associated benthic fish species unsuitable for feeding and reproduction by covering and eliminating available food sources and nest sites. Sediment has been shown to wear away and/or suffocate periphyton (organisms that live attached to objects underwater and provide likely food items for species such as the vermilion darter), disrupt aquatic insect communities, and negatively impact fish growth, physiology, behavior, reproduction and survivability (Waters 1995, Knight and Welch 2001). Sediment is the most abundant pollutant in the Mobile River Basin (Alabama Department of Environmental Management 1996) (USFWS, 2011).

Stressor: Northern crayfish (USFWS, 2011)
Exposure:
Response:
Consequence:

Narrative: The invasive Northern crayfish (Orconectes virilis) has been observed to feed on living watercress darters (Etheostoma nuchali) at Roebuck Spring, Birmingham, Alabama (Duncan et al.2008). The presence of this crayfish has been found simultaneously with the vermilion darter. Brooke (2008) found this species to be the dominate crayfish within the 7.2 mile range of the vermilion darter and more than 60 percent of the crayfish sampled were Orconectes virilis. No predation has been observed but there is a high potential for this to occur (Brooke pers. comm. 2009) (USFWS, 2011).

Stressor: Habitat fragmentation (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Fragmentation of the species' habitat has isolated the populations within the Turkey Creek system and reduced space for rearing and reproduction and population maintenance. Fragmentation and resulting isolated populations has likely reduced adaptive capabilities, and increased the likelihood of local extinctions (Hallerman 2003; Burkhead et al. 1997). Genetic variation and diversity within a species are essential for recovery, adaptation to environmental changes, and long-term viability (capability to live, reproduce, and develop (Noss and Cooperrider 1994; Harris 1984). Long-term viability is founded on numerous interbreeding local populations throughout the range (Harris 1984). Continuity of water flow between suitable habitats is essential in preventing further fragmentation of the species' habitat and populations, conserving the essential riffles, runs, and pools needed by vermilion darters, and promoting genetic flow throughout the populations. Continuity of habitat will maintain spawning, foraging and resting sites as well as providing heterozygosity or gene flow throughout the population. Connectivity of habitats also permits improvement in water quality and water quantity by allowing an unobstructed water flow throughout the connected habitats (USFWS, 2011).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. Populations of vermilion darters and its habitat within its known range in Turkey Creek are shown to be protected from present and foreseeable threats to the point where listing is no longer required through the implementation of activities including stewardship, outreach, best management practices, securing conservation easements or acquisitions, and ensuring adequate regulatory enforcement (USFWS, 2011).

2. Stable or increasing population trends for at least 10 years throughout its known range are verified through monitoring and surveys (USFWS, 2011).

3. Suitable flows (water quantity) and water quality in Turkey Creek supporting the vermilion darter are determined through recovery tasks and assured, through State or local groundwater management plans, or water conservation plans (USFWS, 2011).

4. An average monthly reading of 10 NTU (Nephelometric Turbidity Units), a unit used to measure sediment discharge, or 15 mg/L TSS (Total Suspended Solid) or less discharge into the

Turkey Creek watershed within and upstream of the vermilion darter's range is being attained and documented as occurring for a minimum of 10 consecutive years. Information will be compiled from sampling water quality monthly throughout the year during base, low and high flows (USFWS, 2011).

5. A captive vermilion darter population of 20 pairs (40 individuals) has been established and successfully propagated for augmentation (USFWS, 2011).

Recovery Actions:

- Promote partnerships and voluntary stewardship within the watershed (USFWS, 2007).
- Protect vermilion darter populations and habitat (USFWS, 2007).
- Ensure and support implementation of effective protective actions (USFWS, 2007).
- Determine habitat requirements and population information of the vermilion darter (USFWS, 2007).
- Determine the necessary husbandry techniques of the species, to produce them in captivity (USFWS, 2007).
- Identify, acquire and restore properties in the Turkey Creek watershed (USFWS, 2007).
- Continue implementing recovery actions from the Vermilion Darter Recovery Plan (U.S. Fish and Wildlife Service 2007) (USFWS, 2011).
- Continue protection of the vermilion darter's habitat, maintenance of connections throughout Turkey Creek and tributaries (USFWS, 2011).
- Continue to protect springs, seeps and groundwater within the Turkey Creek Watershed (USFWS, 2011).
- Continue monitoring of the populations structure and genetic variation of the species (USFWS, 2011).
- Work with neighborhood associations and developers to reduce and eliminate unsustainable urbanization on hilltops (USFWS, 2011).
- Continue working with all stakeholders including the City of Pinson, Jefferson County, the State of Alabama, landowners, non-governmental organizations such as the Freshwater Land Trust, Turkey Creek Nature Preserve, and the Black Warrior River Keeper, to protect Turkey Creek, Beaver Creek, the Unnamed Tributary to Beaver Creek, Dry Creek, Dry Branch, Tapawingo Springs and all of spring sites within the area, in particular with regard to storm water runoff and non-point source pollution (USFWS, 2011).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The previous 5-year review included a list of recommendations to improve recovery of the species. Accomplishments toward these recommended actions and future actions needed are summarized below. • Some level of monitoring continues for vermilion darter populations at most localities. Populations of vermilion darters appear to be stable overall, with minor ebb and flow over time of individuals counted. Consistent, standardized monitoring methods are needed across all populations for a long-term period to obtain an accurate assessment of the species' status. • Continue to work with stakeholders to obtain protection of habitat throughout the watershed to ensure removal of threats. • Regular monitoring of the invertebrate biodiversity, gravel erosion, and sediment change in relation to biofilm and periphyton in the Turkey Creek watershed is needed. • Preliminary sampling of EDCs at the Turkey Creek WWTP needs to be expanded into a systematic monitoring program throughout selected areas in the watershed. • Monitoring of basic parameters of water quality data (conducted since 2007, which is archived in the Alabama Water Watch site), needs to continue. • Utilize Partners for Fish and Wildlife Program funding for additional restoration efforts specifically targeting hilltop development to halt the resulting small gravel erosion into Turkey Creek and small tributaries. • Continue to coordinate restoration efforts with stakeholders (the City of Pinson, Jefferson County, the State of Alabama, landowners, FWLT, TCNP, and the Black Warrior River Keepers) to protect Turkey Creek, Beaver Creek, the Unnamed Tributary to Beaver Creek, Dry Creek, Dry Branch, Penny Springs (Tapawingo Plunge). (USFWS, 2019)

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SPECIES ACCOUNT: *Etheostoma chienense* (Relict darter)

Species Taxonomic and Listing Information

Listing Status: Threatened; Southeast Region (R4) (USFWS, 2023). Species Reclassified to Threatened on October 27, 2023.

Physical Description

The relict darter (Etheostoma chienese) is a small fish, usually about 2.5 inches in length, with two dorsal fins, large rounded pectoral fins, thoracic pelvic fins, and a rounded tail fin. They are morphologically distinguished by characterisitics of breeding males, which are gray or dark brown on the dorsum and sides, and light tan on the venter; bright breeding colors do not develop; head and nape are greatly swollen and black (obscures nonbreeding pattern). Females, nonbreeding males, and juveniles have brown mottling on a light tan background; dorsum may be crossed by six to eight small dark brown saddles; venter is white and unmarked; the head has dark pre- and post-orbital bars (Page et al. 1992).

Taxonomy

The relict darter is 1 of 10 recognized species in the Etheostoma squamiceps complex (subgenus Catonotus, family Percidae) (Page et al. 1992, pp. 627-628). It was first discovered in the Bayou de Chien by Webb and Sisk (1975, p. 68, reported as Etheostoma squamiceps), but it wasn't recognized as a distinct species and described until 1992 (Page et al. 1992, p. 627-628). It can be differentiated from the other members of the E. squamiceps complex only by the color and morphology of the dorsal fins of breeding males (Page et al. 1992, pp. 615-646). The relict darter is unique in that the second dorsal fin of each breeding male has two equal branches per ray that are tipped with small white knobs.

Historical Range

Warren et al. (1994, p. 23) speculated that the relict darter was more widespread in the Bayou de Chien basin prior to human settlement, but it was likely restricted to reaches of the watershed lying upstream of the Mississippi River floodplain (presently from about Moscow and upstream). Based on historic and current collection records, they reported that there was no documented evidence that the relict darter ever occurred outside the Bayou de Chien basin (Warren et al. 1994, p. 21-23). In fact, they asserted that it was extremely unlikely that additional populations would be found outside the Bayou de Chien basin because (1) the habitat affinities of the species, (2) the complete allopatry (separation) between it and its closest relatives, (3) the absence of any other species in the E. squamiceps complex in Mississippi River tributaries in Kentucky and Tennessee, and (4) the availability of summaries of species composition in these drainages that did not record the relict darter (Etnier and Starnes 1993, pp. 18-28; Burr and Warren 1986, pp. 369-384).

Current Range

The relict darter is endemic to the Bayou de Chien watershed in Fulton, Graves, and Hickman counties, Kentucky. At the time of listing in 1993, the species was known from only nine sites in the basin (Webb and Sisk 1975, p. 68; Warren and Burr 1991, pp. 6-8, 25; Warren et al., p. 21). Later work by Piller and Burr (1996, pp. 16-18) revealed the presence of the relict darter at 16 of 28 sites surveyed, including 6 new sites. Relict darters were observed at sites on the Bayou de Chien mainstem, South Fork Bayou de Chien, Jackson Creek, Cane Creek, and Sand Creek.

Historic collection localities, including two sites near Moscow, Fulton County, Kentucky, remained void of relict darters (Piller and Burr 1996, p. 50). Based on the this work, the species is known to occupy portions of an approximate 20.1-km (12.5-mile) stream reach of the Bayou de Chien mainstem that extends from the US 51 bridge crossing in Hickman County upstream to the KY 2422 bridge crossing in Graves County (Piller and Burr 1996, p. 17). The largest and most viable population occurs in Jackson Creek (the type locality and best reproductive site for the species), with much smaller populations in South Fork Bayou de Chien, Sand Creek, and Cane Creek. The endemism of the relict darter in Bayou de Chien is unique (Warren et al. 1994, p. 22) as no other fish species shares a similarly restricted distribution anywhere on the northern Gulf Coastal Plain of Arkansas, Kentucky, Missouri, or Tennessee (Pflieger 1975, pp. 1-9; Burr and Warren 1986, p. 369-384; Robison and Buchanan 1988, pp. 3-6, Etnier and Starnes 1993, p. 18-28).

Distinct Population Segments Defined

No (USFWS, 2015)

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: The relict darter's food habits are unknown, but it is assumed that their diet is similar to other members of the E. squamiceps complex (USFWS 1994). As noted by Page (1980, p. 10-11), the diet of related darters consists mainly of aquatic insects and small crustaceans. Juveniles feed on copepods, cladocerans, ostracods, and chironomids, while adults feed mainly on amphipods, isopods, chironomids, and caddisflies.

Reproduction Narrative

Adult: Relict darters are bottom dwellers. Spawning begins in March and lasts until early June. During spawning the female deposits her eggs in a single layer on the underside of a hard substrate. A variety of hard substrates are used as nesting structures including rocks, logs, and tree bark. The male then guards the eggs until they hatch. The food habits of this darter are unknown, but their diet probably consists of aquatic insects and small crustaceans. The only information on reproductive habits of the species was provided by Piller and Burr (1996, pp. 26-31, 36-37) during their investigation in 1995 and 1996. Spawning occurred from mid-March to early June at water temperatures ranging from 11 to 22oC. A total of 166 nests were observed on 16 different substrate types. Most nests were located on natural materials such as small rocks, woody debris, and live tree roots, but 37 percent of nests were found on anthropogenic materials such as rubber tires, plastic, roof shingles, glass, concrete blocks, metal road signs, and concrete slabs. Nests were found at a mean depth of 16.9 cm (6.6 inches [in]) (range of 4.5 to 38 cm [1.8 to 15 in]), and the cavity between the stream bottom and the spawning substrate averaged 2.9 cm (1.1 in) (2 to 5 cm [0.79 to 1.9 in]). Nests with clutches of eggs attached to naturally occurring materials contained a range of 12 to 789 eggs (avg. = 255) in 1995 and from 12 to 1,275 eggs (avg. = 343) in 1996. Because natural spawning substrates were limited in the drainage, Piller and Burr (1996, pp. 31-36) seeded several reaches with ceramic tiles to increase relict darter reproductive success. Between 25 and 88 percent of tiles were utilized for spawning at least once during the study and several were used multiple times. The number of eggs deposited on introduced tiles was significantly larger than the number deposited on natural substrates. Piller and Burr (1996, pp. 37-40) also performed two laboratory experiments to attempt to determine nest preferences of the species. Female relict darters were provided spawning substrates of different sizes. Six of eight laboratory spawnings occurred on the larger substrates, but these differences were not statistically different. In the second experiment, females were added to aquaria with a large (68 to 72 mm [2.7 in to 2.8] standard length [SL, from the tip of the snout to the base of the tail fin] and a small (60 to 64 mm [2.4 to 2.5] SL) male. Seven of eight spawning events occurred with the larger male - a statistically significant result. Several spawnings were videotaped in the laboratory (Piller and Burr 1996, pp. 39-40), and spawning occurred between 20 and 21oC (68 to 70oF). Males and females were positioned in a head-to-head, inverted pattern for 1.5 to 3 seconds, during which time ova were released.

Habitat Narrative

Egg: Fertilized Egg Need Water temperatures 11-22o C (field and laboratory settings); Attachment sites: natural (small rocks, woody debris, and live tree roots) or anthropogenic materials (rubber tires, plastic, roof shingles, glass, concrete blocks, metal road signs, and concrete slabs). (USFWS, 2020)

Larvae: Larvae need Water temperatures >20-21o C (field and laboratory settings); yolk-sac larvae drop to substrate and become benthic immediately upon hatching. (USFWS, 2020)

Juvenile: Juveniles need Slow flowing riffles and pools (0.2-0.6 m/sec) of headwaters and intermediate stream reaches, with cover such as undercut banks, tree roots, and overhanging vegetation and substrates consisting of fine gravel mixed with sand, low amounts of silt, and overlain with leaf litter; food availability – small crustaceans and other invertebrates. (USFWS, 2020)

Adult: The Relict Darter inhabits headwaters and mid-reaches of low-gradient streams, where it is typically observed in slow flowing riffles and pools (0.2-0.6 meters/sec (0.7-2.0 feet/sec)) with gravel and sand substrates (Warren et al. 1994, Piller and Burr 1998, Service 2020). The species has shown an affinity for undercut banks, woody debris piles, and adjacent narrow side channels (2-3 m) underlain by gravel mixed with sand (Warren et al. 1994). Piller and Burr (1998) reported occasional observations of individuals in mid-stream areas with slow flowing water, but rarely was the species observed in riffle habitats (USFWS, 2023).

Dispersal/Migration

Population Information and Trends

Population Size:

14,172-41,424 (USFWS, 2020b)

Population Narrative:

Initial surveys of the Bayou de Chien watershed by Webb and Sisk (1975, p. 68) and Warren et al. (1994, pp. 20-21) revealed that the relict darter was restricted to only nine sites and was known to spawn in only one tributary (Jackson Creek) in the upper reaches of the watershed. Warren et al. (1994, p. 22) estimated the extent (in meters) of suitable habitat at the two sites where relict darters were most abundant, Jackson Creek at Lawrence Road and Bayou de Chien at KY 1283. Their calculations determined that approximately 160 meters (m) (525 feet [ft]) of suitable habitat were present at these two sites, with an estimated population size of 200 individuals (an average of about 1.25 individuals for every 1 m [3.28 ft] of suitable habitat). At remaining sites where Warren et al. (1994, p. 22) found individuals (a total of 8), they estimated the presence of about 35 m (115 ft) of suitable habitat. Piller and Burr (1996, pp. 7-8, 16-17) completed the last comprehensive survey effort for the relict darter. Individuals were found at 16 of 28 sites sampled, with darters inhabiting a total of 47,100 linear m (29.3 miles [mi]) of stream (or 94,200 linear meters [58.6 mi] if you consider both stream banks). Their population estimates taken in the spring of 1996 revealed that the population of E. chienense ranged from 9,553 to 31,293 individuals. The most viable populations were found in areas having gently flowing water, good undercut bank habitat, low silt load, and a suitable quantity spawning substrata or instream cover (Piller and Burr 1996, p. 41). Based on the results of their study, Piller and Burr (1996, p. 50) asserted that E. chienense was maintaining an effective population size.

Threats and Stressors

Stressor: Channelization and Removal of Riparian Vegetation
Exposure:
Response:
Consequence:
Narrative: Stream channelization is a common land practice that is primarily aimed at controlling flooding, increasing the drainage rate of agricultural land, and maximizing the amount of tillable land (Piller and Burr 1996, p. 41). Unfortunately, the extensive alteration of habitats within the Bayou de Chien basin has reduced both relict darter numbers and the amount of suitable habitat for feeding and reproduction. Channelization has impacted the Bayou de Chien system by changing stream flow patterns, reducing instream flows (especially during drier periods), decreasing aquatic habitat complexity, and reducing stream bank and floodplain (riparian) vegetation (Pillar and Burr 1994, p. 41). Channelized reaches have higher stream velocities during high flow periods (which leads to channel instability and bank erosion), less instream cover and habitat for aquatic organisms (decreased habitat complexity), less riparian vegetation and correspondingly reduced canopies (reduced shade), and below normal flows during drier periods (Warren et al. 1994, pp. 23-24; Piller and Burr 1996, pp. 41-42). The relict darter is extremely susceptible to reductions in riparian vegetation because these losses reduce the amount of woody material that is available for cover and reproduction.

Stressor: Siltation
Exposure:
Response:
Consequence:
Narrative: The Bayou de Chien basin is extensively farmed and much of the area has been deforested. These alterations and practices result in a fairly high silt load within the Bayou de Chien system that continues to degrade habitat and impact the species. Sediment (siltation) has been listed repeatedly by the Kentucky Natural Resources and Environmental Protection Cabinet (Division of Water) as one of the most common stressors of aquatic communities in the Bayou de Chien watershed (KDOW 2006, pp. 176-178; KDOW 2008, pp. 166-174). The primary sources of sediment were identified as agriculture (crop production), loss of riparian habitat, impacts from hydrostructure flow regulation and modification, dredging, and channel erosion/incision.

Sediment has been shown to abrade and or suffocate bottom dwelling algae and other organisms, reduce aquatic insect diversity and abundance (the relict darter's prey), and, ultimately, negatively impact fish growth, survival, and reproduction (Waters 1995, pp. 5-7). Wood and Armitage (1997, pp. 211-212) identified at least five impacts of sedimentation on fish, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency.

Stressor: Drainage of riparian wetlands
Exposure:
Response:
Consequence:
Narrative: With increased agricultural activity in the Bayou de Chien basin over the last century, much of the basin has been cleared and many riparian wetlands have been drained to make additional lands available for farming. This has caused an overall reduction in the groundwater level and base flows within Bayou de Chien and its tributaries. Warren et al. (1994, p. 24) and Warren and Burr (1991, p. 16) observed that many small streams in the watershed were completely dry or consisted of isolated pools by the early fall months. These conditions serve to isolate populations and subject both the adults and juveniles to increased pressure from predators (USFWS 1994, p. 14). Warren and Burr (1991, p. 17) asserted that dispersal of the species upstream of the Jackson Creek area or into many downstream tributaries may be limited by in-stream flow conditions.

Stressor: Other Pollutants
Exposure:
Response:
Consequence:
Narrative: In addition to sediment, the Kentucky Natural Resources and Environmental Protection Cabinet (Division of Water) has identified other common stressors (point-source and nonpoint-source pollutants) of aquatic communities in the Bayou de Chien watershed (KDOW 2006, pp. 176-178; KDOW 2008, pp. 166-174). These stressors included iron, lead, excess nutrients, and eutrophication stemming from two suspected sources – municipal point source discharges and agriculture. Three streams, Bayou de Chien (mile 8.8-14.3), Cane Creek (mile 0 to 5.3), and South Fork Bayou de Chien (mile 0 to 2.0), were identified as impaired by the Kentucky Division of Water (KDOW 2008, pp. 166-174). The impacts of lead and iron inputs are unknown, but nutrient inputs and eutrophication can lead to excessive algal growths and in-stream oxygen deficiencies that can seriously impact aquatic species, including the relict darter.

Stressor: Other natural or manmade factors affecting its continued existence
Exposure:
Response:
Consequence:
Narrative: The reduced abundance of relict darters observed by Piller and Burr (1996, p. 16-18) suggests that these populations contribute little to recruitment and rarely interbreed. This prohibits the natural interchange of genetic material between these populations, and the small population size reduces the reservoir of genetic diversity within populations. This can lead to inbreeding depression and reduced fitness of individuals (Soule 1980, pp. 157-158; Hunter 2002,

pp. 97-101). It is likely that some of the relict darter populations are below the effective population size required to maintain long-term genetic and population viability (Soule 1980, p. 162-164; Hunter 2002, pp. 105-107). Climate change has the potential to increase the vulnerability of the relict darter to random detrimental events (e.g., McLaughlin et al. 2002; Thomas et al. 2004). Global warming is expected to result in increasing frequency and duration of droughts and the strength of storms (e.g., Cook et al. 2004). The severe drought that affected western Kentucky in 2007 could be intensified by the effects of global warming.

Recovery

Delisting Criteria:
Criterion 1. Relict Darter populations occupying at least five (5) streams, including the Bayou de Chien mainstem*, Jackson Creek, Little Bayou de Chien, South Fork Bayou de Chien, and one other Bayou de Chien tributary (e.g., Cane Creek), exhibit stable or increasing population trends, natural recruitment, and multiple age classes over a 10-year period (USFWS, 2023).

Criterion 2. Threats have been addressed and/or managed in these watershedsto the extent that the species will maintain resiliency into the foreseeable future (USFWS, 2023).

Recovery Actions:
- 1. Conserve, protect, and enhance existing populations and habitats in the Bayou de Chien system. This action will be achieved through (a) utilization of existing laws, regulations, and policies to protect the species and its habitats; (b) longterm conservation and protection of stream and riparian habitats via conservation easements; (c) implementation of habitat improvement actions such as stream channel restoration, stream bank stabilization, reforestation, livestock exclusion, and other habitat BMPs; and (d) the development and use of new outreach materials that will inform conservation partners and the general public and encourage their participation in conservation efforts (USFWS, 2023).
- 2. Develop and implement a monitoring program and complete searches for new populations (USFWS, 2023).
- 3. Conduct research to monitor the species’ level of genetic exchange, effective population size, and overall genetic diversity (USFWS, 2023).
- 4. Conduct research to determine details of the species’ life history, habitat requirements, and threat sensitivity (USFWS, 2023).
- 5. Develop a captive propagation plan to support ecological research and to prepare for potential augmentation / reintroduction efforts (George et al. 2009) (USFWS, 2023).
- 6. Coordinate all activities and conduct periodic review of recovery progress and strategy (USFWS, 2023).

Conservation Measures and Best Management Practices:
- Initiate efforts to propose reclassifying this fish form endangered to threatened status under the ESA. Complete new draft and final recovery plans. Determine habitat preferences of juvenile and larval Relict Darters. The biology of larvae is unknown. Continue research examining the level of genetic exchange, effective population size, and overall genetic diversity. This will provide important information on the long-term viability of the species and help focus habitat recovery efforts in stream reaches that would improve population connectivity. Continue periodic quantitiative survey efforts (fall surveys) on Bayou de Chien, Jackson Creek, and Little Bayou de Chien. Consider inclusion

of survey reaches on South Fork Bayou de Chien and/or other tributaries and conduct a power analysis to determine if quantitative survey methods should be modified. Search for unknown occupied reaches on other Bayou de Chien tributaries (eg, Cane Creek) and downstream reaches of Bayou de Chien and Little Bayou de Chien. Continue to protect, restore, and enhance habitat quality throughout the drainage, Federal, state, and private parties should continue to work cooperatively (through Farm Bill programs, Partners for Fish and Wildlife projects, etc.) to restore and protect habitats, especially those areas where reproduction and recruitment has been documented (Jackson Creek). The number of permits granted to snag, channelize, or modify the existing stream system should be limited (USFWS, 2020b)

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SPECIES ACCOUNT: *Etheostoma etowahae* (Etowah darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; 12/20/1994; Southeast Region (R4) (USFWS, 2015)

Physical Description

The Etowah darter is a small-sized percid fish, adults being about 45 to 75 mm (1.75-3.0 in) TL. The body is elongate, moderately compressed, and has a moderately pointed snout. The background body color is medium brown or gray-olive. The lower opercle (gill covers) has a have a pale bluish-green wash which is intensified in breeding males. The side is usually pigmented with 13 or 14 small dark blotches just below the lateral line. The breast in breeding males is dark greenish-blue. The spinous dorsal fin is suffused dusky black olive with a red margin. The soft dorsal fin has four bands: dusky black olive on the basal two-thirds, followed by red, white (sometimes with hint of yellow), and black bands of nearly equal width. The caudal (tail) fin is similarly pigmented except the ventral (on the abdominal side of the body) leading rays have a pale blue wash. The anal fin is suffused with greenish-blue and never has red marks, like greenbreast darters do. The pelvic fins are clear to dusky black with a pale green blue wash; pectoral fins are dusky black. All these color patterns are more vivid in breeding males (USFWS, 2000).

Taxonomy

The Etowah darter was formally described out of the greenbreast darter species complex, along with two non-Etowah basin species, E. chuckwachatte, and E. douglasi (Wood and Mayden 1993). The Etowah darter shows little phylogenetic structure throughout its range (Ritchea 2008), suggesting that populations above and below Lake Allatoona should be managed as a single conservation unit. Mitochondrial DNA sequence data revealed a new population of Etowah darter in Raccoon Creek living in syntopy with the greenbreast darter. The mitochondrial DNA analysis also showed haplotypes of both Etowah and greenbreast (Etheostoma jordani) darters in specimens collected from the lower Etowah River mainstem, but the data were insufficient to determine if the two species currently occur together or if the two species overlapped and hybridized at some point in the past (Freeman et al. 2013) (USFWS, 2014).

Historical Range

The Etowah darter is endemic to the Etowah River basin, Georgia. The species, when listed, was known to occur only in the upper Etowah River mainstem above Lake Allatoona and in two tributaries, Long Swamp and Amicalola Creek (USFWS, 2014).

Current Range

Sample collections and genetic analyses conducted since 2000 have extended the known range of the species in the Etowah mainstem upstream several kilometers and identified additional populations in three tributary systems: Shoal (Dawson County), Stamp, and Raccoon Creeks (USFWS, 2014).

Distinct Population Segments Defined

No (USFWS, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Adults and immatures are invertivores (NatureServe, 2015). The greenbreast, and probably the Etowah darter, consumes midge larvae, mayflies, water mites, caddisflies, and occasionally some mollusks (Mettee et al. 1996) (USFWS, 2014).

Reproduction Narrative

Adult: Sexual maturity is usually reached after the first year of a typically three-year life span (USFWS, 2014).

Geographic or Habitat Restraints or Barriers

Adult: Impoundments, upland habitat (inferred from NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Adults typically occur in riffles of streams with moderate to strong current over gravel or cobble substrate (Wood and Mayden 1993). Warm and cool, medium and large creeks or small rivers that have moderate or high gradient and rocky bottoms; in relatively shallow riffles, with large gravel, cobble, and small boulder substrates; typically associated with the swiftest portions of shallow riffles, but occasionally adults are taken at the tails of riffles; most abundant in sites with clear water and relatively little silt in the riffles; shuns pools, intolerant of stream impoundment (USFWS 1993) (NatureServe, 2015).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Not available

Dispersal/Migration Narrative

Adult: This species is non-migratory. Data on dispersal and other movements generally are not available (NatureServe, 2015).

Population Information and Trends

Population Trends:

Unknown (NatureServe, 2015)

Species Trends:

Stable (USFWS, 2014)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

Unknown; possibly < 10,000 (NatureServe, 2015)

Population Narrative:

Total adult population size is unknown but may be fewer than 10,000 adults. Population size at known sites is small. Many sites are represented by only one or very few individuals per sampling effort; significant numbers have only been found in a few localities, including the Etowah headwaters, Shoal Creek (Dawson County), Amicalola Creek, Long Swamp Creek and Raccoon Creek (Freeman and Wenger 2006). This species is represented by populations in the mainstem river and 8 tributaries; within these streams the species is known from about 70 collection sites (Freeman and Wenger 2006). The range extent is 400 - 2,000 square miles. There are 6 - 20 occurrences. Trend over the past three generations is unknown but distribution and abundance probably are slowly declining (NatureServe, 2015). The species status is stable; the major threat to this species, urban development, has been limited since the 2007- 2009 recession on housing and commercial development in the metro-Atlanta area (USFWS, 2014).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The Etowah and Cherokee darter listing document identifies the primary causes of habitat destruction, modification, or curtailment as: impoundments that result in habitat loss, population extirpation, fragmentation, and changes in the thermal regime below dams that favors predatory fishes; siltation associated with timber clearcutting, clearing of riparian vegetation, and construction, mining, and agricultural practices that allow dirt to enter streams; increased development and land clearing that increases siltation from erosion, accelerates runoff, allows transport of pollutants into the Etowah River system, and requires additional road and landfill infrastructure; bridges, railroad crossings, and other stream crossings that are potential sites for spills of toxic material due to vehicle accidents, deliberate dumping, and other means; pollution from other point and nonpoint sources such as municipal and industrial waste discharges, agricultural runoff, poultry processing plants, and silvicultural activities (USFWS, 2014).

Stressor: Stochastic events (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The limited distribution makes this species vulnerable to localized extinction over much of its range in the event of human-caused toxic chemical spills, catastrophic natural events like flood or severe drought, genetic drift, and other stochastic events (USFWS, 2014).

Stressor: Climate change (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The effects of climate change on aquatic species of the Conasauga and Etowah River systems have not been studied. In the Southeast through the 21st century, climate models project that average annual temperatures will increase, cold days will become less frequent, the freeze-free season will lengthen by up to a month, temperatures exceeding 95 degrees will increase, heat waves will become longer, sea levels will rise an average of 3 feet, the number of category 3 to category 5 hurricanes will increase, and air quality will decline (Ingram et al. 2013). Aquatic systems will be impacted by increasing water temperatures, decreasing dissolved oxygen levels, altered streamflow patterns, increased demand for water storage and conveyance structures, and increasing toxicity of pollutants (Ficke 2007, Rahel and Olden 2007). Reduced spring/summer rainfall, coupled with increased evapotransporation and water demand (because of population growth), could lead to local extirpations if streams dry out more frequently (Ingram et al. 2013). Fishes not constrained by movement barriers could move upstream to cooler waters; however, Etowah darters already occur in the headwaters of the Etowah mainstem and occupied tributaries, so upstream range migration would result in a net loss of occupied habitat (USFWS, 2014).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. Known populations of the species are shown to be stable or increasing for at least five years (USFWS, 2014).

2. Plans are developed to protect and monitor water and habitat quality in all occupied streams (USFWS, 2014).

Recovery Actions:
- Protect habitat integrity and quality (USFWS, 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS, 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS, 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS, 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS, 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS, 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS, 2000).

- Reintroduce aquatic species into restored habitats, as appropriate (USFWS, 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS, 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS, 2000).
- Work with local governments in the Etowah River basin to develop a new HCP(s) or other basin wide management plan to protect aquatic resources (USFWS, 2014).
- Develop a conservation banking program in the Etowah River basin to compensate for loss of aquatic habitats that support Etowah, Cherokee, and amber darters (USFWS, 2014).
- Work to establish a Conasauga River conservation area to protect high priority amber darter reaches (USFWS, 2014).
- Fund annual long-term monitoring of these species in the Etowah and Conasauga basins (USFWS, 2014).
- Develop a baseline database on stream geomorphic characteristics in high quality Cherokee darter streams. Use these data to revise stream restoration methods commonly used in the basin to ensure development of habitat for benthic shoal-dwelling fishes is a primary restoration project component (where applicable) (USFWS, 2014).
- Complete the chemical profile of the Conasauga. If agricultural contaminants appear to be a major stressor on amber darters and other protected and rare species in the Conasauga, work with NRCS to reduce input into the River (USFWS, 2014).
- Complete the study to evaluate intersex fish incidence in the Conasauga. Concurrently, evaluate the effect of environmental estrogens on public health and communicate these results to GEPD and local governments (USFWS, 2014).
- Develop and implement programs and materials to educate government officials and the public on the need and benefits of ecosystem management and to involve them in watershed stewardship for these and other aquatic species (USFWS, 2014).
- Work with GEPD and EPA to incorporate listed species' review into NPDES point-source and construction permit review (USFWS, 2014).
- Continue to hold periodic Conasauga and/or Coosa Summits to bring together researchers, land managers, environmental groups, local government officials, and others to discuss recent Conasauga/Coosa research results, new threats, and needed management actions. Continue to meet in smaller committees, as needed, to discuss management actions to address stressors (USFWS, 2014).

Conservation Measures and Best Management Practices:

- Recommendations for future actions: The following are future actions for Etowah darter recovery: 1. Work with local governments in the Etowah River basin to continue improving local ordinances that minimize impact of development on water quality and suitable habitat. 2. Continue to establish mitigation options that benefit Etowah darter including conservation banking. 3. Fund annual long term monitoring of Etowah darter status surveys to determine if Criteria 1 is being met. 4. Develop a baseline database on stream geomorphic characteristics in high quality Etowah darter streams. Use these data to revise stream restoration methods commonly used in the basin to ensure development of habitat for benthic shoal dwelling fishes is a primary restoration project component (where applicable). 5. Develop and implement programs and materials to educate government officials and the public on the need and benefits of ecosystem management and to involve the in watershed stewardship for Etowah darter and other aquatic species. 6. Continue to work with GA DNR, TNC and other partners to protect high quality lands throughout the Etowah Watershed 7. Work with GEPD and EPA to incorporate listed species review into NPDES point-source and construction permit review. 8. Continue to hold periodic Coosa Summits to bring together researchers, land managers, environmental groups, local government officials, and others to discuss recent Coosa research results, new threats and needed management actions. Continue to meet in smaller committees, as needed, to discuss management actions to address stressors. (USFWS, 2021)

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SPECIES ACCOUNT: *Etheostoma fonticola* (Fountain darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/13/1970; Southwest Region (R2) (USFWS, 2016)

Physical Description

The fountain darter is a small (adults average slightly larger than 1 inch total length), benthic, reddish brown fish (Page and Burr 1979). There are about eight stitch-like marks along the sides (Jordan and Evermann 1896).

Historical Range

The fountain darter was historically found in the Comal and upper San Marcos rivers (Service 1996a) (Figures 1 and 2). The type specimens were collected from the San Marcos River immediately below the confluence with the Blanco River in 1884 (Jordan and Gilbert 1886). The first records from the Comal River consisted of 43 specimens collected in 1891 (Evermann and Kendall 1894).

Current Range

This darter is endemic to the upper San Marcos and Comal rivers in central Texas (Hubbs et al. 2008). San Marcos and Comal rivers are spring-fed streams deriving from the Edwards Aquifer. The original population in the Comal River was extirpated in the mid-1950s when Comal Springs ceased to flow (Hubbs et al. 2008). A population from San Marcos was reintroduced into Comal Springs during the early 1970s (Hubbs et al. 2008).During periods of low flows, the National Fish Hatchery and Technology Center in San Marcos, Texas, serves as a refugium (Bonner and McDonald 2005). The fountain darter is known to have been present in the San Marcos River from the headwaters (including Spring Lake) downstream to the vicinity of Martindale in Caldwell County (Service 1996a). Fountain darters can currently be found Spring Lake to a point between the San Marcos Waste Water Treatment Plant (WWTP) outfall and the confluence with the Blanco River (Service 1996b). Researchers have estimated the San Marcos River population of the fountain darter to total 45,900 individuals (downstream of and excluding Spring Lake) (Linam 1993), to as many as 103,000 (Schenck and Whiteside 1976). Fountain darter densities appear to be highest in the upper segments of the San Marcos River and decrease markedly in an area below Cape's Dam (Linam 1993, Whiteside et al. 1994). The fountain darter population was extirpated from the Comal River system in the mid-1950s (Schenk and Whiteside 1976). In 1954, rotenone was applied to the Comal system to remove non-native and exotic fish, and fountain darter populations may have been adversely impacted to an unknown degree by this effort (Ball et al. 1952, Service 1996a). The primary cause of extirpation, however, is thought to be the 1949-1956 drought of record (DOR). The most likely cause of the extirpation of the fountain darter in the Comal River system was the cessation of Comal Springs flows for 144 days from June to November, 1956 (Schenck and Whiteside 1976). This event likely resulted in significant temperature fluctuations in remaining pools of water, decreased habitat and water quality, and increased predation of fountain darters. Intensive surveys from 1973 to 1975 were unable to verify presence of the species in the Comal River system. From February 1975 through March 1976 about 450 fountain darters collected from the San Marcos River were released into the headsprings of the Comal River and into the old Comal River channel. By June of 1976, five offspring were found a short distance below the headsprings, confirming recruitment and re-establishment of a population (Schenck and Whiteside 1976). Fountain darters now occupy Comal Springs and the Comal River from Landa Lake downstream to the confluence with the Guadalupe River. A 1990 survey estimated that the Comal River population totaled about 168,078 individuals between the headwater springs and Clemens Dam (Linam et al. 1993). The fountain darter occupies virtually all of the Comal River and most of the San Marcos River above the confluence of the San Marcos River and Blanco River (Figures 1 and 2). In The Comal River system, the only habitats not likely to support fountain darters are the upper reach of Comal Springs spring run No. 2, which has little vegetation. In the case of spring run No. 2, the wading pool weir acts as a fish barrier. One factor that degrades the fountain darter habitat in lower Comal Springs spring run No. 1 and the embayment of Landa Lake is the intense herbivory by non-native (and native) waterfowl, which has eliminated most rooted macrophytes and reduced fountain darter habitat suitability. The Service and cooperators surveyed for fountain darters in the action area from July 1993 to April 1994, and in July 1996 (Service 1996b). The fountain darter abundances in spring runs 1, 2, and 3 were low compared to nearby habitat in Landa Lake and Comal River new channel. Dammeyer (2010) conducted a mark and recapture study in the Comal River old channel and estimated the number of fountain darters in a 100 m section as 2,732. Assuming homogeneity of channel width, habitat quality, and fountain darter density throughout the Comal River old channel (the old channel is 2,550 m long), the fountain darter population in the old channel is estimated at 6,967. The EARIP (2012) used a STELLA® model to estimate fountain darter numbers in the Comal system for average to low springflow for their HCP documentation. The median (50th percentile) discharge for monthly springflow at Comal Springs is 295 CFS. For the U.S. Geological Survey's period of record for Comal Springs (1932 to present), a discharge of 225 CFS falls near the 23rd percentile. At 225 CFS total springflow, the model estimates an average of 114,837 fountain darters (EARIP HCP 2012).

Critical Habitat Designated

Yes; 7/14/1980.

Legal Description

On July 14, 1980, the Service determined critical habitat for Etheostoma fonticola (Fountain darter) in San Marcos, Texas. This rule provides the full protection of the Endangered Species Act of 1973, as amended, to this species (45 FR 47355 - 47364)

Critical Habitat Designation

The critical habitat designation for Etheostoma fonticola includes two areas in Hays county, Texas. The areas are Spring Lake and its outflow, and the San Marcos River, downstream approximately 0.5 miles below Interstate Highway 35 bridge.

Unit descriptions not available.

Primary Constituent Elements/Physical or Biological Features

Not described. The preferred habitat of adult and young fountain darters are areas with rooted aquatic vegetation which grows close to the substrate with filamentous algae present (Schenk and Whiteside, 1976).

Special Management Considerations or Protections

Actions which would reduce or eliminate the fountain darter populations include the destruction or significant reduction of aquatic vegetation in Spring Lake and the san Marcos River;

impoundments; excessive withdrawal of water; and pollution.

Life History

Feeding Narrative

Adult: Invertebrate food supply of living organisms (copepods, dipteran (fly) larvae, and mayfly larvae)

Reproduction Narrative

Adult: Fountain darters spawn year-round (Schenck and Whiteside 1977b). Some authors have described two peak spawning periods, one in August and another late winter to early spring (Schenck and Whiteside 1977b), while others have suggested that fountain darter reproduction may be tied to habitat quality (BIO-WEST 2007). Some data supports year-round reproduction in areas of high-quality habitat in both the Comal and San Marcos systems (e.g., Spring Lake, Landa Lake), with a strong spring peak in reproduction (with limited reproduction in summer and fall of most years) in areas of lower quality habitat farther downstream (BIO-WEST 2007). Fountain darter eggs have been found attached to bryophytes and algae in Spring Lake and on filamentous algae Rhizoclonium sp., and native and non-native submergent macrophytes, including Hygrophila polysperma, Hydrilla verticillata, Ludwigia repens, Sagittaria sp., and Texas wild-rice in the San Marcos River (Dowden 1968, Phillips and Alexander unpublished data). After hatching, fry are not free swimming, in part due to the reduced size of their swim bladders.

Habitat Narrative

Adult: Fountain darters prefer undisturbed stream floor habitats; a mix of submergent plants (algae, mosses, and vascular plants), in part for cover; clear and clean water; an invertebrate food supply of living organisms (copepods, dipteran (fly) larvae, and mayfly larvae); constant water temperatures within the natural and normal river gradients; and adequate springflows (Bergin 1996, Schenck and Whiteside 1977a). Fountain darter densities are lower in areas lacking vegetation (Institute of Natural Systems Engineering 2004, BIO-WEST 2006, BIO-WEST 2013).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Population Information and Trends

Population Size:

774,000 individuals within the Comal River system (including Landa Lake). BIO-WEST estimates 480,000 individuals within the San Marcos River, and 455,400 individuals within the high quality habitat within Spring Lake (414,000 square feet with estimated fountain darter densities of 1.1 darter per square foot)

Population Narrative:

Current population estimates place the fountain darter population at about 774,000 individuals within the Comal River system (including Landa Lake). BIO-WEST estimates 480,000 individuals within the San Marcos River, and 455,400 individuals within the high quality habitat within Spring Lake (414,000 square feet with estimated fountain darter densities of 1.1 darter per square foot) (BIO-WEST 2011). Most recent work on population trends for fountain darters has been performed by BIO-WEST, which has surveyed for fountain darters since 2000 (Perkins et al. 2018, pp. 58-86). The number of darters from 2002-2010 was estimated to be 58,562 to 471,315 in the San Marcos River, excluding Spring Lake (EARIP HCP 2012, p. 4-127). Population estimates including Spring Lake would likely be much higher (EARIP HCP 2012, p. 3-58). Spring Lake is not sampled by drop netting, but dip net and benthic transects indicate high abundance of darters there (BIO-WEST 2019b, p. 33). The population estimates of fountain darters in the Comal River in representative reaches were 32,829-147,358 (EARIP HCP 2012, pp. 4-76-4-77). Population estimates for the entire Comal River would be higher, but were not calculated. Estimating the population size of fountain darters is difficult and often results in large confidence intervals (EARIP HCP 2012, pp. 3-57-3-58). Different sampling methods have also been used in different studies that may prevent direct comparison of population estimates. (USFWS, 2021)

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative: The San Marcos and Comal Springs and Associated Aquatic Ecosystems Recovery Plan identifies several threats to the fountain darter (Service 1996a). The primary threats are related to the quantity and quality of aquifer and spring water. Drought conditions, groundwater use, and lower than average springflows threaten the species recovery. Activities that may pollute the Edwards Aquifer and its springs and streamflows may also threaten the species. Additional threats include effects from increased urbanization near the rivers; recreational activities; habitat modification; predation, competition, and habitat alteration by non-native species; and the effects of introduced parasites (Service 1996a). Fountain darters appear to be a pollution sensitive species and require high quality water, which is provided by the Edwards Aquifer. Groundwater contamination or pollution resulting from a catastrophic event such as a hazardous material spill into the Comal or upper San Marcos rivers constitutes another threat to the species. The Comal River and Landa Lake and their immediate tributaries are crossed by a total of 19 bridges including three railroad bridges; and the upper San Marcos River including Spring Lake and their immediate tributaries are crossed by a total of 30 bridges including four railroad bridges and six associated with Interstate Highway 35. Any of these river crossings could be the source of a spill or release that could affect the species or its designated critical habitat in the San Marcos River. Stormwater inflows and other non-point sources of contamination may also pose a threat to the species. Recreational use of the San Marcos River can also result in adverse impacts to fountain darters. Recreation in the San Marcos River has been reported as seasonal, with the highest use during summer months, holidays and weekends (Bradsby1994). Recreational uses that physically alter habitats or that result in loss of aquatic vegetation, such as trampling or uprooting vegetation, may affect the fountain darter’s ability to feed and shelter. Fountain darters reproduce by adhering eggs to aquatic plants (Dowden 1968, Phillips and Alexander unpublished data). Impacts to vegetation that supports fountain darter eggs could affect breeding success. Non-native species can threaten fountain darters though competition, habitat disturbance, and parasitic infection. Introduced fishes found in these river systems include tilapia (Cichlidae) that disrupt substrates thereby increasing turbidity and alter habitats

by clearing areas of aquatic vegetation, thereby potentially affecting fountain darter sheltering and breeding habitats. Suckermouth catfishes (Loricaridae) disrupt substrates and may burrow into and destabilize riverbanks, thereby introducing additional sediment loads and turbidity into the river systems. Another non-native species that threatens the fountain darter is a parasitic trematode that attacks the fish's gills (Mitchell et al. 2000 and McDonald et al. 2006). The trematode is native to Southeast Asia, and is associated with the presence of a non-native snail in the Comal and San Marcos systems. The adverse effects of these parasites on their fountain darter hosts is believed to increase during stressful conditions associated with low flow rates (Cantu 2003 and McDonald et al. 2007), and the parasite's adverse effects may have greater effects on younger fountain darter life-Stages (McDonald et al. 2006). Currently, the trematode is more prevalent in the Comal system. In the San Marcos system the parasite is somewhat localized to river reaches near IH-35. A concern is the potential spread of the trematode throughout this system (through movement of various fish, snails, and avian intermediate hosts) thus adversely affecting the entire San Marcos fountain darter population. This environmental baseline describes the current status of the species and is based upon impacts to which the species has been exposed (Service and NMFS 1998). To understand the potential effects of the currently authorized and actual pumping amounts as managed by the existing Edwards Aquifer Authority (EAA) Critical Period Management (CPM) plan, springflow was modeled for a 54-year period (1947 through 2000) that included a range of precipitation conditions including the DOR event that occurred from 1949 to 1956. The reduction and loss of springflows projected by these modeling efforts during severe drought conditions could have significant impacts to the fountain darter in both the Comal and San Marcos River systems.

Recovery

Delisting Criteria:

The fountain darter will be considered for delisting when the following criteria are met: 1. The mean daily discharge in the Comal River as measured by the New Braunfels streamflow gage (USGS 08169000) is equal to or greater than 100 cfs, 95 percent of the time, over 30 years with no zero flow days. The mean daily discharge in the San Marcos River as measured by the San Marcos streamflow gage (USGS 08170500) is equal to or greater than 50 cfs, 95 percent of the time, over 30 years with no zero flow days. These instream flows are met even in a repeat of the drought of record. Justification: The fountain darter occurs only in the Comal River of Comal County, Texas and the upper San Marcos River of Hays County, Texas. Thus, both river systems are considered crucial to the viability of the species. Criterion 1 supports the fullest extent of habitat in both the Comal and upper San Marcos rivers by ensuring the primary determinant of structure and function of this aquatic ecosystem (its flow regime) is continuously supporting the only two populations of fountain darter. Poff et al. (2010) provided a consensus view of the importance of limiting hydrologic alterations. The Service has provided minimum flows needed to avoid jeopardy in the current Recovery Plan (1996) pursuant to litigation (Sierra Club vs. Secretary of the Interior (No. MO-91- CA-069, U.S. Dist Ct., W.D. Texas). Continuous flows above 150 cfs at Comal Springs are needed to prevent jeopardy to the fountain darter. Additionally, continuous flows above 100 cfs at San Marcos Springs are needed to prevent jeopardy to the fountain darter. 2. The populations are equal to or greater than 500,000 individuals in the both the Comal and San Marcos river systems consecutively for 30 years (based on a Service approved sampling design). Justification: Larger population sizes are better able to adapt to changing environmental conditions over time, and thus more resilient. Large populations help avoid the myriad of negative effects common to small populations such as loss of genetic variation and increased likelihood that random events may result in loss of one or both populations. A population of greater than or equal to 500,000 individuals at the headwater of each spring ecosystem is considered to be: (1) realistic, assuming aquatic habitats are restored to the carrying capacity of Landa Lake and Spring Lake, (2) sustainable, given a stable spring flow regime with adequate submergent aquatic macrophytes, (3) practical, given the areal extent of suitable habitat in each ecosystem, and (4) a population size large enough to maintain genetic variation and avoid adverse effects related to small population size. 3. The mean weekly water temperature is less than or equal to 76 degrees Fahrenheit for30 years. Water temperature will be measured at six representative designated sites (three sites in Landa Lake and three sites in Spring Lake) in 15 minute intervals using USGS NFM protocols and procedures. Justification: Maintenance of water temperature will help each spring ecosystem realize its maximum potential habitat. When fountain darters are present throughout their lake-river system's historic range, they are less likely to suffer an extirpation or extinction event. Water quality, (particularly a higher than average spring-ambient water temperature regime due to low springflow) in 1956 is considered to be an important factor in the extirpation of the fountain darter from the Comal River. The relation of water quality especially water temperature to fountain darter egg production and mortality of larvae has been researched at the San Marcos Aquatic Resources Center and Texas State University (Bonner et al. 1998). 4. Dissolved oxygen measured as the daily minimum at a height of 15 cm above the river bed in six designated sites (three in Landa Lake and three in Spring Lake) exceeds 4.0 mg/L for 95 percent of the time over 30 years. Additionally, dissolved oxygen as measured above must exceed 2.0 mg/L 100 percent of the time. Justification: Adequate dissolved oxygen is at the critical to the health of fishes and other aquatic organisms. Impairment of dissolved oxygen could lead to morbidity or mortality of fountain darters or their prey items. Figure 2. Fountain darter segments for the Comal River System. The U.S. Geological Survey station for the Comal River is located at the boundary of sections 10 and 11 (Bartsch et al. 1999) (USFWS, 2019).

Recovery Actions:

- The San Marcos and Comal Springs and Associated Aquatic Ecosystems Recovery Plan (Service 1996a) that includes fountain darter, identifies specific recovery actions including ensuring adequate flows and water quality in the San Marcos River; maintenance of genetically diverse reproductive populations in captivity and creation of reintroduction techniques for use in the event of a catastrophic event; removal or reduction of threats due to non-native species, recreational use of the river, and habitat alteration; and maintenance of healthy, self-sustaining, reproductive populations in the wild.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Revise the 1996 San Marcos & Comal Springs & Associated Aquatic Ecosystems (Revised) Recovery Plan when schedule permits to include recovery actions that incorporate new information and can be evaluated using the data currently collected for the species. • Revise Downlisting Criterion 1. Because future climate is expected to become drier in the region, a plan for aquifer management based on the drought of record is not protective of more severe droughts that have been projected by scientific studies. Future climate modeling should be used reevaluate the amount of groundwater that can sustainably be withdrawn during dry conditions expected in the future and to better understand the relationship between future air temperature and water temperature in the San Marcos and Comal rivers. • Revise Downlisting Criterion 4. Because current data collection occurs due to monitoring for the EARIP HCP (2012), it is recommended that the vegetation goals be adjusted to match the goals used in the EARIP HCP. The goals for darter densities should also be updated to reflect the densities that are used by the EARIP HCP (2012, pp. 4-10, 4-30). • Meeting species-specific vegetation goals is less important for fountain darters than the total amount of coverage of high quality native aquatic vegetation to provide habitat for fountain darters. Thus, it would make sense to combine the species-specific goals for vegetation for a total areal coverage goal for native vegetation for each spring reach. • Sample fountain darters outside of representative reaches to better assess overall population status. • Increase reproduction in the captive refugia now that a large wild-caught stock exists in captivity. Create a genetics management plan to determine the minimum number of wild caught individuals necessary to maintain genetic diversity in captivity. Remove the requirement to maintain fountain darters from the Comal River based on genetic evidence that they are subset of the genetic diversity from the San Marcos River. (USFWS, 2021)

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SPECIES ACCOUNT: *Etheostoma moorei* (Yellowcheek Darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; 9/8/2011; Southeast Region (R4) (USFWS, 2015)

Physical Description

A 60-mm fish (darter). A small darter with a moderately sharp snout, a compressed, deep body, and a deep caudal peduncle (Robison and Allen 1995). (NatureServe, 2015)

Taxonomy

"Distinctive taxon of unquestioned validity" (Starnes 1995). (NatureServe, 2015)

Historical Range

The yellowcheek darter (Etheostoma moorei) is endemic to the Devil's, Middle, South, and Archey forks of the Little Red River in Cleburne, Searcy, Stone, and Van Buren Counties in Arkansas (Robison and Buchanan 1988, p. 429). These streams are located primarily within the Boston Mountains subdivision of the Ozark Plateau (USFWS, 2012).

Current Range

Range encompasses the upper Little Red River drainage (White River drainage) above Greers Ferry Lake in Cleburne, Searcy, Stone, and Van Buren counties, Arkansas (Robison and Buchanan 1988). Much of the original range was inundated by Greers Ferry Lake in the early 1960s. Remaining populations occur in the following tributaries of the Little Red River: South Fork, Middle Fork, Archey Creek, and Devils Fork (including Turkey Fork [at least formerly] and Beech Fork segments) (Mitchell et al. 2002, USFWS 2011), although the Devils Fork population is now highly reduced or extirpated (Wine et al. 2000).Extent of occurrence is less than 2,000 square kilometers (probably greater than 1,000). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Legal Description

On October 16, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Etheostoma moorei (Yellowcheek darter) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes four critical habitat units (CHUs) in Arkansas (77 FR 63604-63668).

Critical Habitat Designation

The critical habitat designation for Etheostoma moorei includes four CHUs in Cleburne, Searcy, Stone, and Van Buren Counties, Arkansas (77 FR 63604-63668).

Unit 1: Middle Fork of the Little Red River, Searcy, Stone, and Van Buren Counties, Arkansas

Unit 2: South Fork of the Little Red River, Van Buren County, Arkansas

Unit 3: Archey Fork of the Little Red River, Van Buren County, Arkansas

Unit 4: Devil's Fork of the Little Red River (including Turkey Creek and Beech Fork), Stone and Cleburne Counties, Arkansas

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Etheostoma moorei critical habitat consists of five components in Arkansas (77 FR 63604-63668): Within these areas, the primary constituent elements of the physical and biological features essential to the conservation of the yellowcheek darter consist of five components: (i) Geomorphically stable, second- to fifth-order streams with riffle habitats, and connectivity between spawning, foraging, and resting sites to promote gene flow within the species' range where possible. (ii) Stable bottom composed of relatively silt-free, moderate to strong velocity riffles with gravel, cobble, and boulder substrates. (iii) An instream flow regime (magnitude, frequency, duration, and seasonality of discharge over time) sufficient to provide permanent surface flows, as measured during years with average rainfall, and to maintain benthic habitats utilized by the species. (iv) Adequate water quality characterized by moderate stream temperatures, acceptable dissolved oxygen concentrations, moderate pH, and low levels of pollutants. Adequate water quality is defined for the purpose of this rule as the quality necessary for normal behavior, growth, and viability of all life stages of the yellowcheek darter. (v) Prey base of aquatic macroinvertebrates, including blackfly larvae, stonefly larvae, mayfly nymphs, and caddisfly larvae.

Special Management Considerations or Protections

The four units we are designating as critical habitat for the yellowcheek darter will require some level of management to address the current and future threats to the physical and biological features of the species. The yellowcheek darter is currently covered under a candidate conservation agreement with assurances (CCAA) in the upper Little Red River watershed in Arkansas, along with the endangered speckled pocketbook mussel, which does not have critical habitat designated. Of the 205,761 hectares (ha) (508,446 acres (ac)) within the upper Little Red River watershed known to support the yellowcheek darter, approximately 35,208 ha (87,000 ac) are owned by private parties (Service 2007, p. 4). To date, multiple landowners have enrolled 4,672 ha (11,544 ac) in the program since its inception in mid- 2007, and 10 more landowners with approximately 20,234 ha (50,000 ac) have pending draft agreements. Lands enrolled in these conservation programs include areas within the critical habitat as well as riparian and upland areas that are outside of the critical habitat boundary. Various activities in or adjacent to critical habitat may affect one or more of the physical and biological features. For example, features in this critical habitat designation may require special management due to threats posed by natural gas extraction; timber harvest; gravel mining; unrestricted cattle access into streams; water diversion for agriculture, industry, municipalities, or other purposes; lack of adequate riparian buffers; construction and maintenance of county and State roads; and nonpoint source pollution arising from development and a broad array of human activities. These threats are in addition to random effects of drought, floods, or other natural phenomena. Other activities that may affect physical and biological features in the critical habitat units include those listed in the Effects of Critical Habitat Designation section below. Management activities that could ameliorate these threats include, but are not limited to: Use of BMPs designed to reduce sedimentation, erosion, and bank side destruction; moderation of surface and ground water withdrawals to maintain natural flow regimes; increase of stormwater management and reduction of stormwater flows into the systems; preservation of headwater springs and streams; regulation of offroad vehicle use; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the areas we are designating as critical habitat for the yellowcheek darter contain the physical or biological features for the species, and that these features may require special management considerations or protection. Special management consideration or protection may be required to eliminate, or to reduce to negligible levels, the threats affecting the physical or biological features of each unit.

Life History

Feeding Narrative

Adult: Primary foods are aquatic dipteran larvae (chironomids and simuliids); also eats immature stoneflies, mayflies, and caddisflies (Robison and Buchanan 1988). Adults and immatures are invertivores (NatureServe, 2015). Aquatic macroinvertebrate prey items; permanent surface flows, as measured during average rainfall years; moderate to strong water velocity in riffles; and adequate water quality are an essential physical or biological feature for the yellowcheek darter (USFWS, 2012).

Reproduction Narrative

Adult: Spawns from late May through June; sexually mature in one year; lives up to 4 years (Robison and Buchanan 1988). Spawning occurs in swifter, turbulent portions of riffles around or under the largest substrate particles available (lower portions of riffles) (Wine et al. 2000) (NatureServe, 2015). Wine and Blumenshine (2002, p. 10) noted that during laboratory spawning, yellowcheek darter females bury themselves in fine gravel or sand substrates (often behind large, fist-sized cobble) with only their heads and caudal fin exposed. A yellowcheek darter male will then position himself upstream of the buried female and fertilize her eggs (USFWS, 2012).

Geographic or Habitat Restraints or Barriers

Adult: Impoundments, upland habitat (inferred from USFWS, 2012)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow to moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This fish occupies small to medium, high gradient, clear rivers, in swift to moderate riffles with gravel, rubble, and boulder bottoms (Robison and Buchanan 1988, Page and Burr 2011). Juveniles occur in shallow riffles; adults commonly are found at depths of 10-20 inches (Robison and Allen 1995). Podostemon often grows in inhabited riffles (NatureServe, 2015). Habitat connectivity is essential to accommodate feeding, breeding, growth, and other normal behaviors of the yellowcheek darter and to promote gene flow within the species (USFWS, 2012). The Yellowcheek Darter inhabits high-gradient headwater tributaries with clear water, permanent flow, moderate to strong riffles, and gravel, cobble, and boulder substrates (Robison and Buchanan 1988) (USFWS, 2018).

Dispersal/Migration

Motility/Mobility

Adult: Moderate (inferred from USFWS, 2012)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (USFWS, 2012)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015). Weston and Johnson (2005, p. 24) observed that the yellowcheek darter moved very little during a 1-year migration study, with 19 of 22 recaptured darters found within 9 m (29.5 ft.) of their original capture position after periods of several months (USFWS, 2012).

Population Information and Trends

Population Trends:

70-90% decline (NatureServe, 2015)

Species Trends:

Species Status: Declining (USFWS, 2019).

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

2500 - 100,000 individuals (NatureServe, 2015)

Population Narrative:

Most of the best habitat was destroyed by inundation and cold tailwater releases from Greers Ferry Reservoir (USFWS 2011). Estimated population size declined from approximately 60,000 in 1978-1981 (Robison and Harp 1981) to 10,300 in 2000 (Wine et al. 2000). Subsequently, an increase may have occurred (USFWS 2011). This species has experienced a long-term decline of 70-90%. A thorough survey in 2000 yielded an estimated population size of approximately 10,300 individuals (uncertain whether this refers to adults or all individuals), with 6,000 in Middle Fork, 2,300 in South Fork, and 2,000 in Archey Fork (none were found in the Devils Fork system) (Wine et al. 2000). Weston and Johnson (2005, cited by USFWS 2011), estimated yellowcheek darter populations within the Middle Fork to be between 15,000 and 40,000 individuals, and between 13,000 and 17,000 individuals in the South Fork. Confidence in these estimates is low, so it is unclear whether these numbers reflect a true increase in the populations (USFWS 2011). Each of the 3-4 occupied tributaries can be considered to be a single occurrence or subpopulation, separated by the reservoir. The range extent is 250 - 5,000 square miles (NatureServe, 2015). As stated earlier, of the four streams supporting the yellowcheek darter, only the South and Archey forks maintain a non-inundated confluence. Instream habitat at the confluence of the two streams is suboptimal due to previous channelization, but restoration could provide an opportunity for vital population interactions between streams to maintain genetic diversity. Fragmentation of the species' habitat has subjected these small populations to genetic isolation (USFWS, 2012).

Threats and Stressors

Stressor: Habitat modification and degradation (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: threats to the yellowcheek darter from the present destruction, modification, or curtailment of its habitat or range negatively impact the species. Threats include such activities as impoundment, sedimentation, poor livestock grazing practices, improper timber harvest practices, nutrient enrichment, gravel mining, channelization/channel instability, and natural gas development. These threats are considered imminent and of high magnitude throughout the species' entire range (USFWS, 2011).

Stressor: Restricted range and population size (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: The yellowcheek darter has a limited geographic range and small population size. The existing populations are extremely localized, and geographically isolated from one another, leaving them vulnerable to localized extinctions from intentional or accidental toxic chemical spills, habitat modification, progressive degradation from runoff (non-point source pollutants), natural catastrophic changes to their habitat (e.g., flood scour, drought), other stochastic disturbances, and to decreased fitness from reduced genetic diversity. Additionally, populations are below the effective population size required to maintain long-term genetic and population viability (Soule 1980, pp. 162–164; Hunter 2002, pp. 105–107) (USFWS, 2011).

Stressor: Climate change (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Climate change is expected to result in increased frequency and duration of droughts and the strength of storms (e.g., Cook et al. 2004). Climate change could intensify or increase the frequency of drought events, such as the one that occurred in 2007. Thomas et al. (2004, p. 112) report that the frequency, duration, and intensity of droughts are likely to increase in the Southeast as a result of global climate change (USFWS, 2011).

Recovery

Reclassification Criteria:

Not available - this species does not have a recovery plan.

Delisting Criteria:
For the Yellowcheek Darter to be considered as recovered, the following criteria must be met: (1) water quality and quantity in the (1) Middle, (2) South and (3) either Archey or Devils Forks1 as defined by the best available science (to be refined by recovery actions), supports the long-term survival ofYellowcheek Darter in its natural environment (based on Safe Harbor enrollment and private landowner conservation efforts) (addresses Factors A, D, and E); (2) streams where the Yellowcheek Darter occurs contain geomorphically stable channels with relatively silt-free, moderate to strong velocity riffles with gravel cobble and boulder substrates that support adequate macroinvertebrate prey items, as defined by reference stream conditions in the Boston Mountain ecoregion (addresses Factors A, D, and E); (3) healthy, self-sustaining (evident by multiple age classes of individuals, including naturally recruited juveniles, and recruitment rates exceeding mortality rates) natural populations ofYellowcheek Darters, as defined by the best available science (to be refined by recovery actions), are maintained in three of four tributaries (Middle, South, and either Archey or Devils Forks) at stable or increasing levels during a 30-year period (trend based on surveys conducted every three years via standard protocol and incorporating species recovery period from extreme droughts) (addresses Factors A and E); and (4) a captive propagation, augmentation and reintroduction plan has been established, and a contingency plan is in place to ensure the survival of the species should a catastrophic event affect portions of a wild population (addresses Factor E). (5) The measures mentioned above have been realized and demonstrated effective via monitoring efforts (addresses Factors A, D, and E); (6) Commitments are in place to maintain conservation measures and recovered status (addresses Factor A) (USFWS, 2018).

Recovery Actions:
- Actions Needed: (1) Aid in recovery of the Yellowcheek Darter by protecting the habitat integrity and quality of stream reaches that currently support or could support the Yellowcheek Darter (Priority 1)2. Stemming the decline and loss of aquatic habitats throughout the known range of the Yellowcheek Darter is essential for recovery of the species. Stream reaches known to be occupied by endangered or threatened aquatic species are generally protected by provisions of the Endangered Species Act from federally funded or permitted actions that could adversely modify supporting habitats or jeopardize the continued existence of the animal. Non-federal activities on private lands that comprise the bulk ofYellowcheek darter habitat require proactive efforts by the Service and natural resource managers to work cooperatively with private landowners to achieve recovery objectives. (2) Promote voluntary stewardship as a practical and economical means of reducing nonpoint source pollution from private land use (Priority 2). Best Management Practices (BMPs) can be effective and practical actions identified to prevent or reduce nonpoint source pollution from specific land use activities. For example, agricultural BMPs are designed to reduce sediments, animal wastes, fertilizers, and pesticides in storm water runoff (Benthrup 2008). Silviculture BMPs include actions to minimize sediments, nutrients, organics, other chemicals, and stream canopy removal (AFC 2002). Natural gas development BMPs have been created specifically to address such activities in the Fayetteville Shale region of Arkansas (Service 2009; Service 2007). BMPs are developed by state and industry planning partnerships with public participation, and can be effective when they are properly implemented and adequately maintained. BMPs, however, are not always fully implemented or maintained. Industry groups and organizations, and state resource agencies

should continue to promote and improve BMPs when necessary as a non-regulatory approach to aquatic habitat management. (3) Develop a spill prevention and management plan for the upper Little Red River watershed (Priority 3). A plan to avoid catastrophic spills of pollutants and/or contaminants within streams of the upper Little Red Watershed should be developed and implemented. Chemicals used in the hydraulic fracturing process for natural gas extraction and other potentially detrimental chemicals are routinely transported across streams supporting the Yellowcheek Darter. Appropriate plans of action for responding to potentially catastrophic spills are essential to aid municipalities in mitigating contamination of drinking water and other environmental resources. Methodology for evaluating the effectiveness of this plan should be developed and that effectiveness should be monitored and evaluated regularly, and as necessary, modified as new information and/or hazardous materials information becomes available. (4) Conduct research to aid recovery efforts for the Yellowcheek Darter (Priority 2). General aspects of the biology and ecology of the Yellowcheek Darter have been studied, but some data gaps persist. This information may provide insight into past declines, current status of the species, vulnerabilities in the life cycle, and management guidance for future recovery efforts. This information will also help natural resource managers better assess the effects of anthropogenic influences such as natural resource extraction, silviculture, infrastructure development, etc. on Yellowcheek Darter populations. All partners should be aware of research efforts and results, so that information can be immediately applied. (5) Develop and implement a monitoring protocol for the Yellowcheek Darter (Priority 3). Periodic surveys of occupied stream reaches, as well as those known to be historically occupied by the species, should be performed in a repeatable fashion. Yellowcheek Darter habitat and population sizes should be monitored to assess the efficacy of conservation measures implemented for recovery of the species. Surveys should be conducted range wide for the species every three years using a rigorous approach to model gear efficiency (e,g., Peterson and Paukert 2009) or detectability (e.g., Magoulick and Lynch 2015). Changes in distribution/abundance (losses and gains), habitat quality, etc. should be used to focus recovery efforts and adjust priorities as needed. Adequately fund stream gages within the watershed to monitor flow trends and stream drying (USFWS, 2018).

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. The AES, in cooperation with ANHC and AGFC, should develop a population monitoring plan for each fork of the Little Red River. 2. The AES should continue to foster a working partnership with landowners, municipalities, industry, NGOs, and State and Federal agencies to address and minimize threats. 3. The AES should work with TNC and County Road Departments to improve implementation of the unpaved roads program BMPs with specific emphasis placed on high priority road segments identified in TNC's unpaved roads inventory. 4. The AES should prioritize protection of water quality and quantity by working with AGFC, NRCS, and nonprofit organizations to obtain conservation easements, perpetual private lands agreements, and fee-simple acquisitions. 5. All three authorized entities should continue SHA enrollment of landowners. 6. The AES should work with TNC, NRCS, AGFC, and private landowners to stabilize stream channels in the Upper Little Red River. 7. The AES should work through Section 7 Inter-agency Consultation with U.S. Army Corps of Engineers to review water management at Greers Ferry Lake and minimize threats associated with inundation of Yellowcheek Darter habitat while providing flood control. 8. The AES should coordinate with Arkansas Natural Resources Commission to establish a Watershed Management Plan for the Little Red River (USFWS, 2019).

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SPECIES ACCOUNT: *Etheostoma nianguae* (Niangua darter)

Species Taxonomic and Listing Information

Listing Status: Threatened; 06/12/1985; Great Lakes-Big Rivers Region (R3) (USFWS, 2016)

Physical Description

Etheostoma nianguae is a large, slender darter with a long head that tapers into a slender, pointed snout. The background coloration is yellowish-olive, with eight prominent saddle bars along the back, and orange spots scattered over the upper sides. A series of U-shaped greenish blotches alternate with narrow orange bars along the mid-side. Two small, jet black spots are present at the base of the caudal fin (USFWS, 1989).

Taxonomy

Its only near relative is the arrow darter, Etheostoma sagitta (Jordan and Swain), which is similarly localized in the Cumberland and Kentucky stream systems of eastern Kentucky and northern Tennessee. These two darters are the sole members of the subgenus Litocara, as first proposed by Bailey (1948) (USFWS, 1989).

Historical Range

The Niangua darter no longer occurs in the Niangua River near Marshfield, suggesting that its distribution in that stream has been reduced since the time of its original discovery. Populations of the Niangua darter in Maze (Arbell) Creek and Little Pomme de Terre River have apparently been extirpated since 1970. Others were probably extirpated before the distribution of the species was adequately documented (USFWS, 1989).

Current Range

This darter is rare and localized in north-flowing tributaries of the Osage River, Missouri River basin, Missouri (Figg 1993, Pflieger 1997, Page and Burr 2011): Maries River and Little Maries Creek (Osage County); Big Tavern Creek, Barren Fork, Brushy Fork, and Little Tavern Creek (Miller County); Niangua River and Greasy Creek (Dallas County); Little Niangua River (apparently the most secure population), Starks Creek, Thomas Creek, and Cahoochie Creek (Camden, Hickory, and Dallas counties); Pomme de Terre River (Benton, Green, and Webster counties); Brush Creek and Panther Creek (Cedar and St. Clair counties) (possibly extirpated); Bear Creek; and the North Dry Sac River (Polk County). Formerly the species was more widespread and abundant within these river systems (NatureServe, 2015). No new populations have been found; however, range extensions have been noted. Since the Niangua Darter was listed, the MDC has documented the following new Niangua Darter occurrences: downstream extension on the Little Niangua River (Camden Co.), downstream extension on the Niangua River (Dallas Co.), downstream extension on the Pomme de Terre River (Polk Co.), downstream extension on Tavern Creek (Miller Co.), discovery in Little Tavern Creek and Kenser Creek (Miller Co.), discovery in Little Wilson Creek (Polk Co.), and discoveries in Macks Creek and Fiery Fork (Camden Co.) (MDC 2012) (USFWS, 2019).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 6/12/1985.

Legal Description
On July 12, 1985, the Service determined the Niangua darter (Etheostomo nianquae) to be a threatened species and designated critical habitat in Miller County, Missouri, under the authority contained in the Endangered Species Act of 1973, as amended.

Critical Habitat Designation
The critical habitat designation for Etheostoma nianguae includes Big Tavern Creek in Miller County, Missouri; Niangua River in Dallas County, Missouri; Pomme de Terre River in Greene County, Missouri; Brush Creek in Cedar and St. Clair Counties, Missouri; and Little Niangua River in Camden, Dallas, and Hickory Counties, Missouri.

Big Tavern Creek and 50 feet along each side of the creek from Highway 52 upstream to Hiehway 17.

Niangua River and 50 feet on each side of the river,from county road K upstream to 1 mile beyond county road M to the Webster County line.

Pomme de Terre River and 50 feet on each side of the river from Highway 65 upstream to the Webster County line.

Brush Creek and 50 feet on each side of the creek from 1000 feet upstream of county road J to the boundary of Sections 54 and 35. Township 36 N. Range 25 W.

Little niangua River and 50 feet on each side of the river from 1 mile below (downstream of) Highway 54, Camden County, to county road E. Dallas County.

Primary Constituent Elements/Physical or Biological Features
Constituent elements for all aras designated as critical habitat consist of:

medium-sized creeks with silt-free pools and riffles and moderately clear water draining hilly areas underlain by chert and dolomite;

water ranges from 8 to 46 inches in depth over gravel with scattered rubble.

Special Management Considerations or Protections
Stream channelization projects, often associated with road and bridge construction and maintenance, may result in erosion and siltation and affect the proposed critical habitat. Currently, there are no known or planned road or bridge projects within or in the vicinity of the proposed critical habitat. In addition, there is no known involvement of Federal funds or Permits for the activities occurring on private land within the proposed critical habitat area.

Life History

Feeding Narrative
Adult: Adults and immatures are invertivores. It eats mainly stonefly and mayfly nymphs gleaned from interstices of stream bottom (Lee et al. 1980) (NatureServe, 2015). Some benthic

insects (larvae of caddisflies and blackflies; certain stonefly nymphs) are rarely eaten even though they are common components of the biota, indicating selectivity in feeding habits (USFWS, 1989).

Reproduction Narrative

Adult: Spawns in April at about 18oC. Eggs are not guarded. Apparently sexually mature in 1-2 years; lives to 4+ years (Page 1983, Kuehne and Barbour 1983, Hubbs 1985, Bart and Page 1992). Spawning occurs on swift gravel riffles; eggs are laid while the female is buried in gravel. (NatureServe, 2015). None of the three age groups in which both sexes were represented exhibited a significant departure from a 1 to 1 sex ratio. The female burrows into gravel substrate and the male takes a position above her as the eggs are deposited and fertilized. The number of mature ova averaged 189.8 for four females of age-group I, 387.5 for two females of age-group II. A female of age-group IV had 7148 mature eggs (USFWS, 1989).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat; elevations of 230 - 250 m (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (USFWS, 1989)

Environmental Specificity

Adult: Narrow (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from USFWS, 1989; see dispersal/migration narrative)

Habitat Narrative

Adult: Habitat includes rocky pools and runs of clear creeks and small to medium rivers (Page and Burr 2011); this darter avoids headwater creeks and large Ozark rivers. Most of the year it occurs in shallow pools and runs having slight currents and gravel or rock substrates (Lee et al. 1980). It may favor "stream reaches with relatively intact banks and riparian corridors, and less agricultural development" (Figg and Bessken 1995). In the Little Niangua River, darters were found disproportionately in reaches (1) located in the mid- to lower sections of the stream (elevations of 230 - 250 m), (2) with riffles spaced 40-80 m apart or with gradients of 2-4 m per km, and (3) with relatively uneroded banks; within occupied reaches, darters were commonly in microhabitats 20 - 40 cm deep with substrate particles averaging 3 - 5 cm in diameter (Mattingly and Galat 2002). See Mattingly and Galat (1998, 2002) for further information. Separation barriers include dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). This species exhibits a clumped or non-random distribution, suggesting that it is somewhat gregarious or is restricted to certain stream pools by habitat scarcity (USFWS, 1989).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015); possibly seasonal movements, based on closely related species (USFWS, 1989)

Dispersal

Adult: Low (inferred from USFWS, 1989)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015). Individual Niangua darters were observed in the same general area over a period of days or weeks. No data are available on movements or migrations, but other darters are known to move upstream in early spring (USFWS, 1989).

Population Information and Trends

Population Trends:

stable or increasing (USFWS, 2019)

Species Trends:

10 - 30% decline (NatureServe, 2015)

Number of Populations:

5 known extant, 8 total (USFWS, 2024)

Population Size:

2,300 - 27,000 (USFWS, 1989)

Additional Population-level Information:

At the time of listing, the Niangua Darter was known to occur in approximately 128 miles (205 kilometers (km)) within eight of ten north-flowing Osage River tributaries. Critical habitat for the Niangua Darter was also designated for 90 of these miles (145 km) within the Niangua, Little Niangua, Pomme de Terre rivers, and Tavern and Brush creeks. Two populations (Maze Creek and Little Pomme de Terre) are now thought to be extirpated due to effects resulting from impoundments (Figure 1). Based upon MDC long-term monitoring information, the five Niangua Darter populations being monitored have expanded since its listing as portrayed in Figure 1 using the current range compared to the critical habitat designation. While this expansion may be attributable to regular monitoring efforts, the construction of aquatic organism passage (AOP) projects should also be credited for the movement of Niangua Darters into suitable habitat. While no new populations have been found, five of the eight populations are considered steady or increasing with two additional range extensions noted during this review period. One extension occurred in Rabbithead Creek within the Tavern Creek population and the second was in Fiery Fork Creek within the Little Niangua River (Figure 1). Notably, the latter was the second extension reported for Fiery Fork Creek and attributed to an AOP project completed in 2019 (Westhoff and Decoske 2020). Other range extensions were noted in the previous status review (USFWS 2019). In contrast, persistence of the three Niangua Darter populations in the Sac River Basin (Brush Creek, Bear Creek, and the North Dry Sac River) remains in question. The Service and MDC conducted separate visual survey (snorkeling) efforts in known locations and a few streams containing suitable habitat characteristics for the species. In 2023, MDC also completed an eDNA surveillance effort for the presence of Niangua Darter DNA from sites at or near historical locations in Bear Creek, Brush Creek, and the North Dry Sac River. These surveys yielded no visual observations of Niangua Darters nor positive eDNA detections (Sterling et al. 2020, Rochon et al. 2021, MDC 2023 unpublished data). Despite not finding recent occurrences within the three Sac River tributaries, it is possible the Niangua Darter may still occur in unsearched streams within the basin. Thus, we still consider the Niangua Darter as extant in all eight populations accounting for approximately 269.5 stream miles (433.7 stream km) (USFWS, 2024).

Population Narrative:

This species is rare and localized (Pflieger 1997). This species has experienced a short term decline of 10 - 30%; stream miles of occupied habitat declined from 142 miles in the 1970s to not more than 115 miles in the 1990s, and fish densities appeared to decline in most populations. Figg and Bessken (1995) commented that survey results suggest "a continuing decline in populations." (NatureServe, 2015). It is composed of eight known populations which occupy 138 stream miles in the Ozark Region of west-central Missouri. A rough estimate of the total number of Niangua darters in all populations combined was obtained by Pflieger (1976). These computations suggested that the total number of Niangua darters was probably between 2,300 and 27,000 individuals. Historical data are insufficient to determine long-term trends in distribution and abundance (USFWS, 1989). While the population appears to be stable or increasing in the streams studied, viable populations have not been discovered or established in four additional stream drainages; therefore, recovery criteria have not been met (USFWS 1989) (USFWS, 2019)

Threats and Stressors

Stressor: Reservoir construction (USFWS, 1989)
Exposure:
Response:
Consequence:
Narrative: Reservoir construction appears to be the principal threat to survival of the Niangua darter. Four major reservoirs (Lake of the Ozarks, Pomme de Terre Reservoir, Stockton Reservoir, and Truman Reservoir), are within the range of this species (Fig. 1). These reservoirs have adversely affected Niangua darter populations through inundation of stream habitat, range fragmentation, and the influx of fish species favored by the reservoirs into tributary streams. The full extent of these impacts on the Niangua darter is not known, since most of the reservoirs were completed before the distribution of this species had been adequately documented. Reservoir construction creates insurmountable barriers to the dispersal of the Niangua darter between suitable habitats. Such movements are essential for maintaining populations in streams where local extirpation occurs as a result of environmental extremes or other factors. Movements may also be important in maintaining gene flow and genetic diversity (USFWS, 1989).

Stressor: Predatory fish (USFWS, 1989)
Exposure:
Response:
Consequence:
Narrative: The influx of species favored by the reservoir into tributary streams my increase competition or predation. The log perch, a potential competitor with the Niangua darter, is often favored by reservoir construction. The largemouth bass and the spotted bass are favored by reservoirs and are potential predators. The spotted bass Micropterus punctulatus, the rock bass (Ambloplites rupestris), and Ozark bass (Ambloplites constellatus) were introduced by 19110, and

are now widely distributed in streams where Niangua darters occur. All are to some extent piscivorous and thus are potential predators of the Niangua darter (USFWS, 1989).

Stressor: Habitat degradation (USFWS, 1989)
Exposure:
Response:
Consequence:
Narrative: The accelerated conversion of woodlands to pasture in recent years is one factor. Increased sedimentation and nutrient enrichment are likely results of this activity. Stream channelization is not as extensive within the range of the Niangua darter as it is in some areas of Missouri, but is still a factor in habitat destruction. It has been common practice to channelize streams for a short distance above and below new road bridges. Landowners also channelize streams to control local flooding. Another common practice detrimental to stream habitat is the removal of willows and other woody vegetation from the stream channel, on the assumption that this increases water carrying capacity and reduces bank erosion. This results in greater instability of the substrate. There is little doubt that all of the factors discussed above contribute to a general reduction of the quality of stream habitat (USFWS, 1989). Habitat conditions suitable for Niangua Darter populations are still negatively influenced by anthropogenic land-use activities and infrastructure. Streams supporting Niangua Darter populations are degraded through increased sediment loading and the continued use of low-water crossings (USFWS 2017). Poorly designed low-water crossings can negatively impact aquatic organism passage and local habitat quality which can further impact population size and distribution. Efforts continue to replace low-water crossings with designs to improve both aquatic organism passage and habitat quality throughout the Niangua Darter range. Westhoff and Decoske (2016) reported that 20 road crossings, including 14 of the 32 crossings identified by Novinger et al. (2008) have been completed as of December 2016. MDC continues to provide comprehensive monitoring near these crossings to evaluate the biological and physical habitat responses. (USFWS, 2019)

Stressor: Increased average water temperature (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Furthermore, a predicted increase in average water temperature (2–4 °C) throughout the Ozarks of Missouri may also negatively affect the Niangua Darter population (Faulkner 2015). Future studies should be considered to investigate temperature tolerances and potential impacts to Niangua Darter reproduction and survival (USFWS, 2019).

Stressor: Disease or predation (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: The movement of previously introduced predatory fishes such as Spotted Bass (Micropterus punctulatus) from artificial impoundments into tributary streams inhabited by the Niangua Darter was indicated as a potential threat upon population levels. However, the Niangua Darter is sympatric with the Smallmouth Bass (Micropterus dolomieu) which is also an abundant predatory fish. Nonetheless, the possible threat from predatory effects is a valid topic and warrants further study, particularly in the Sac River tributary streams where Niangua Darter populations appear to have declined (USFWS, 2024).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. The eight known populations must be made secure by reducing existing and potential threats to the greatest extent possible and population size is stable or increasing (USFWS, 1989).

2. Viable populations have been discovered or established in four additional stream drainages (USFWS, 1989).

Recovery Actions:
- Survey streams to establish the present status of Niangua darter populations (USFWS, 1989).
- Develop a strategy for establishing additional Niangua darter populations (USFWS, 1989).
- Protect and enhance habitat for existing and introduced Niangua darter populations (USFWS, 1989).
- Develop and implement a program for monitoring Niangua darter populations and habitat (USFWS, 1989).
- The final rulemaking for the Niangua darter included the designation of 90 of the 138 miles of stream currently known to be occupied by the species, plus a 50-foot riparian zone along each side of these streams, as critical habitat (USFWS, 1989).
- The final rule making also includes a provision allowing take of the Niangua darter for conservation purposes if a valid state collecting permit is first obtained and all other state laws and regulations are followed. This special rule will allow for more efficient management of the species, thereby facilitating its conservation (USFWS, 1989).
- A proposal is under review that would restrict the use of designated pesticides within a buffer zone (20 yards for ground application and 100 yards for aerial application) along approximately 1110 miles of stream in 11 Missouri counties for protection of the Niangua darter (USFWS, 1989).
- Three towns within the range of the Niangua darter (Humanaville, Fair Grove, and Strafford) are upgrading facilities for the treatment of sewage effluent discharged into streams inhabited by the Niangua darter. These improvements should enhance water quality in the impacted streams (USFWS, 1989).
- The Missouri Department of Conservation has purchased approximately 5 .5 miles of frontage along four streams that support the Niangua darter. Most of these frontages are quite small, but provide some opportunity for habitat protection and enhancement. The most significant of these acquisitions is the Birdsong Wildlife Area on Brush Creek, which supports a substantial population of the Niangua darter (USFWS, 1989).
- RECOMMENDATIONS FOR FUTURE ACTIONS: • Coordinate with the USFWS Missouri Private Lands Office to investigate opportunities to provide technical assistance to landowners pertaining to the benefits of restricting livestock from streams inhabited by Niangua Darters and evaluate available incentives to landowners for building fences, providing alternative water sources, and planting riparian vegetation to protect stream banks and prevent fertilizer and pesticide run-off into streams. • Continue to cooperate with counties and the

Missouri Department of Transportation in designing and constructing road crossings that eliminate passage barriers for the Niangua Darter. • Coordinate with the Federal Emergency Management Agency when providing funding during a disaster declaration to repair/replace damaged road infrastructure with designs that facilitate aquatic organism passage. • Coordinate with the USACE on activities requiring section 404 permits to refine and improve best management practices that will help reduce impacts to the Niangua Darter. • Collaborate with MDC on their annual Niangua Darter monitoring programs and additional research priorities/opportunities, as well as future genetic and population studies (specifically, additional population status studies targeted in the Sac River tributaries), and investigations of potential habitat improvement projects, easements, and/or land acquisitions to help protect Niangua Darter habitat (USFWS, 2019).

Conservation Measures and Best Management Practices:

- Recommendations for future actions: Coordinate with the USFWS Missouri Private Lands Office to investigate opportunities to provide technical assistance to landowners pertaining to the benefits of restricting livestock from streams inhabited by the Niangua Darters and evaluate available incentives to landowners for building fences, providing alternative water sources, and planting riparian vegetation to protect stream banks and prevent fertilizer and pesticide run-off into streams. Continue to cooperate with counties and the Missouri Department of Transportation in designing and constructing road crossings that eliminate passage barriers for the Niangua Darter. Coordinate with the Federal Emergency Management Agency when providing funding during a disaster declaration to repair/replace damaged road infrastructure with designs that facilitate aquatic organism passage. Collaborate with MDC on their annual Niangua Darter monitoring programs and additional research priorities/opportunities, as well as future genetic and population studies (specifically, additional population status studies targeted in the Sac River tributaries) and investigations of potential habitat improvement projects, easements, and/or land acquisitions to help protect Niangua Darter habitat (USFWS, 2019)
- Recommendations for activities within the next status review period • Develop a Niangua Darter Recovery Team meeting schedule to promote regular discussions among primary members. • Review of the Niangua Darter Recovery Plan by the Recovery Team to itemize information deficiencies. • Develop a Niangua Darter Recovery Implementation Strategy (RIS) • Synthesize Niangua Darter detection needs/efforts in the Sac River basin to guide management in the watershed and understand implications for the species. • Continue to coordinate with the Service's Missouri Private Lands Office to investigate opportunities to provide technical assistance to landowners. Evaluate available incentives to landowners for building fences, providing alternative water sources, and planting riparian vegetation to protect stream banks and prevent fertilizer and pesticide run-off into streams. • Continue to cooperate with counties and the Missouri Department of Transportation in designing and constructing road crossings that eliminate AOP barriers for the Niangua Darter. • Continue to coordinate with the Federal Emergency Management Agency when providing funding during a disaster declaration to repair/replace damaged road infrastructure with designs that facilitate AOP. • Continue to coordinate with the USACE on activities requiring Clean Water Act Section 404 permits to refine and improve best management practices that will help reduce impacts to the Niangua Darter. • Continue to collaborate with MDC on their annual Niangua Darter monitoring programs and additional research priorities/opportunities, as well as future genetic and population studies (specifically, additional population status studies targeted in the Sac River tributaries), and investigations of potential habitat improvement projects, easements, and/or land acquisitions to help protect Niangua Darter habitat (USFWS, 2024).

- The MDC developed a Best Management Practices (BMP) pamphlet for the Niangua Darter indicating its ecology, reasons for decline, specific and general recommendations regarding topics affecting the Niangua Darter and its habitat. They hosted stream crossing workshops for road department employees and bridge engineers that highlighted guidelines for crossing construction and maintenance activities that benefit Niangua Darter. The MDC also regularly composes articles within its Missouri Conservationist magazine specifically mentioning the Niangua Darter, the importance of protecting stream environments and adjacent riparian corridors, as well as outdoor activities involving streams; all of which help to increase awareness regarding conservation of imperiled species and their habitats. The Service also provided a Biological Opinion to the USACE since the 2019 5-Year Review which included several recommendations to not only protect the Niangua Darter during project activities but also consider possible restoration opportunities including additional AOP projects, stream crossing design improvement, incorporating principles of natural channel design as described in NRCS (2007) and Harman and Starr (2011) to benefit small aquatic organisms, as well as investigations within understudied reaches (USFWS, 2024).

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SPECIES ACCOUNT: *Etheostoma nuchale* (Watercress darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/13/1970; Southeast Region (R4) (USFWS, 2015)

Physical Description

The watercress darter is a small, robust species growing to a maximum size of just over 5 centimeters (2 inches) in total length. Breeding males have red-orange and blue fins, and red-orange on the lower part of the body. The lateral line has 35 to 42 scales, is incomplete, and has 12 to 24 pored scales. The nape is naked (USFWS, 1992).

Taxonomy

Phylogenetic evaluation of polyallelic loci by Mayden et al. (2005) supported the specific recognition of E. nuchale. (NatureServe, 2015)

Historical Range

The watercress darter is endemic to limestone springs in the Black Warrior River system, Valley and Ridge Physiographic Province, Jefferson County, Alabama: Glenn, Thomas, and Seven springs (Valley Creek system) and Roebuck Spring (Village Creek system) (Howell and Davenport 2003, Kuhajda 2003, Boschung and Mayden 2004) (USFWS 2009).

Current Range

The species has been introduced into several springs, with apparent success only in Tapawingo Spring (Boschung and Mayden 2004). (NatureServe, 2015)

Distinct Population Segments Defined

No (USFWS, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Adults and immatures are invertivores. Eats snails, crustaceans, and insect larvae (Page 1983, Mettee et al. 1996) (NatureServe, 2015).

Reproduction Narrative

Adult: Gravid females are found March-July (NatureServe, 2015). Aquatic vegetation also plays an important role as the substrate upon which the darter lays its eggs (Stiles 1986) (USFWS, 1992).

Geographic or Habitat Restraints or Barriers

Adult: Dams, upland habitat, waterfalls (NatureServe, 2015)

Habitat Narrative

Adult: These darters inhabit slow-moving waters of springs and spring runs; usually they are taken from dense mats of watercress or other aquatic vegetation, where they rest on stems and leaves well above soft substrates (Kuehne and Barbour 1983, Mettee et al. 1996, Boschung and Mayden 2004, Page and Burr 2011). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Not available (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Data on dispersal and other movements generally are not available (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 30-50% (NatureServe, 2015)

Species Trends:

Declining (USFWS, 2009)

Number of Populations:

4 (USFWS, 2022)

Population Size:

10,000 - 100,000 individuals (NatureServe, 2015)

Additional Population-level Information:

Details of the history of the known springs can be found in the 1993 recovery plan and the 2009 5-year review (Service 1993, 2009). Since the previous 5- year review and recovery plan, watercress darters have been discovered in one new spring system (Cunningham Creek) and the documented range of the Roebuck Spring population has expanded. Watercress darters can now be found within six springs and comprise of four distinct genetic populations (USFWS, 2022).

Population Narrative:

Fairly regular monitoring of known populations indicated a continuing decline in abundance in the 1980s and 1990s (Moss 1995). This species has experienced a long-term decline of 30-50%. Total adult population size is unknown but exceeds 10,000 (see USFWS 2009). This species is represented by only a few occurrences (subpopulations) (Mettee et al. 1996, Boschung and Mayden 2004). Fluker et al. (2007) reported that the species occurs in five known localities. (NatureServe, 2015). The species status is declining based on the decline in population numbers and habitat condition at a primary population in 2008. The watercress darter lives within the appropriate habitat of approximately 6.2 acres of spring pools and 7900 feet of spring run in the five spring locations (calculated from Maptech 2002). Genetic diversity of the watercress darter populations has likely declined due to isolation over time of the populations in the Valley and Village Creek drainages within the Black Warrior River system (USFWS, 2009).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: The watercress darter is vulnerable to non-point source pollution, urbanization, and changes in groundwater and surface water flow due to its localized distribution in five spring sites within two stream drainages. Since watercress darters are associated with spring ecosystems, spring water quality, and quantity are essential for producing a flushing and cleansing effect of the spring pools and spring runs. Destruction or alteration of this water would significantly threaten and reduce the species' ecology including spatial and temporal movements. Spring water may be impacted by site specific spring head disturbances rather than overall spring drainage disturbances (Drennen 2004). Within the five watercress darter spring sites, all aquifer recharge areas are vulnerable to contamination from the land surface (Kopaska-Merkel et al. 2005). Non-point source pollution from land surface runoff can originate from virtually any land use activity and may be correlated with impervious surfaces and storm water runoff. Pollutants may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of subsurface and surface waters such that the habitat and food sources for species like the watercress darter are negatively impacted. Construction and road maintenance activities associated with urban development typically involve earth-moving activities that increase sediment loads into nearby aquatic systems through storm water runoff during and after precipitation events. Excessive sediment and increased turbidity can make the habitat of watercress darters and associated benthic fish species unsuitable for feeding and reproduction by covering and eliminating available food sources and nest sites (USFWS, 2009).

Stressor: Predation (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Immediately after the dam removal, the remaining wetlands of the Roebuck Spring pool and parts of the spring run, because of the lack of habitat and cover, supported high densities of the exotic Northern Crayfish, Orconectes virilis (Duncan et al. 2008). Duncan et al. (2008) witnessed crayfish attempting predation on watercress darters 10 days after the dam removal. Duncan et al (2008) sampled crayfish and watercress darters on September 22, 2008, and found an approximate 1:1 ratio of crayfish to watercress darters. This suggested that the watercress darters might be rapidly 15 decreasing due to the concentration of both crayfish and watercress darters within the remaining habitat. Carroll et al. (2009) believed that the Northern crayfish could exacerbate the recovery of the watercress darter within the spring pool and have a significant impact on the species in the spring run (USFWS, 2009).

Stressor: Stochastic events (USFWS, 2009)

Exposure:
Response:
Consequence:
Narrative: The species is vulnerable to catastrophic events such as chemical spills or modification of the spring basin due to the accessibility of the spring sites. The loss of approximately one-half of the genetic component, based on the 11,760 watercress darter individuals lost at Roebuck Spring (Fluker and Kuhajda 2009, Duncan et al. 2008) may present genetic risks and corresponding population problems (Hallerman 2003) in the spring pool (USFWS, 2009).

Stressor: Disease or predation (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: The movement of previously introduced predatory fishes such as Spotted Bass (Micropterus punctulatus) from artificial impoundments into tributary streams inhabited by the Niangua Darter was indicated as a potential threat upon population levels. However, the Niangua Darter is sympatric with the Smallmouth Bass (Micropterus dolomieu) which is also an abundant predatory fish. Nonetheless, the possible threat from predatory effects is a valid topic and warrants further study, particularly in the Sac River tributary streams where Niangua Darter populations appear to have declined (USFWS, 2024).

Stressor: Other natural or manmade factors affecting its continued existence (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: A predicted increase in average water temperature (2–4 °C) throughout the Ozark Region of Missouri may negatively affect the Niangua Darter populations (Faulkner 2015). Future studies that investigate temperature tolerances and potential impacts to Niangua Darter reproduction and survival should be considered. Impacts of sedimentation on habitat quality and successful recruitment is suspected to negatively affect species conservation and recovery. Therefore, a specific study to acquire this information is warranted (USFWS, 2024).

Stressor: Beaver Activity (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Excessive beaver activity can have negative impacts on watercress darter habitat and active management is required to keep beaver populations in check. Seven Springs has experienced negative impacts from beaver activity in past years (USFWS, 2022)

Recovery

Reclassification Criteria:
1. Long-term protection of the three known naturally occurring populations (i.e., those found in Glenn, Thomas (Watercress Darter National Wildlife Refuge (WDNWR)), and Roebuck Springs, Jefferson County, Alabama (USFWS, 2009).

2. Long term protection of at least one additional population within the historical range (USFWS, 2009).

3. Five years of data indicating that a minimum of four populations are viable (USFWS, 2009).

Recovery Priority Number: 2 (USFWS, 2022)

Delisting Criteria:
1. Five years of data documenting the existence of six viable populations, each in separate discrete recharge areas (USFWS, 2009).

2. Long-term protection of the discrete recharge area for each viable population (USFWS, 2009).

Recovery Actions:
- Monitor habitat and populations (USFWS, 1992).
- Maintain and enhance habitat (USFWS, 1992).
- Manage watercress darter populations (USFWS, 1992).
- Obtain long-term authority to manage and protect watercress darter habitat (USFWS, 1992).
- Continue implementing recovery actions from the Watercress Darter Recovery Plan (U.S. Fish and Wildlife Service 1993) (USFWS, 2009).
- Incorporate additional recovery actions prepared and discussed in 2006 by stakeholders (Drennen, memo 2006) into the recovery actions detailed by the Watercress Darter Recovery Plan (USFWS, 2009).
- Continue working with all stakeholders including government entities, landowners, non-governmental organizations, and the City of Pinson and Bessemer in protecting all of the spring sites, in particular with regard to storm water runoff and non-point source pollution (USFWS, 2009).
- Continue efforts with the DYS and the City of Birmingham to manage the Roebuck Spring system including the spring pool and run (USFWS, 2009).
- Continue working with Faith Apostolic Church in managing and protecting Seven Springs (USFWS, 2009).
- Continue to support and assist the Watercress Darter National Wildlife Refuge (Thomas Springs) in management of this system (USFWS, 2009).
- Continue contact and offering technical advice to the new landowner of Glenn Spring (USFWS, 2009).
- Continue to work with the Freshwater Land Trust in conservation and management of the Tapawingo Spring system (USFWS, 2009).

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIVITIES Details of the recovery actions for the watercress darter can be found in the 1993 recovery plan and the 2009 5-year review (Service 1993, 2009). New recommendations are provided below: • Continue to work with the Freshwater Land Trust in conservation and management of Penny Springs, lower Seven Springs run/Nabors Branch system and additional upland habitat improvements at other watercress darter locations. • Conduct genetic analysis at the Cunningham Creek location to better determine/confirm the genetic distinctiveness of this population. • Assess Thomas Creek population (WDNWR) to better determine post restoration project benefits. • Survey tributaries to Roebuck Spring and Village Creek to better

understand species distribution. • Evaluate and implement connectivity improvements for watercress darter passage where applicable. • Work with Lakewood Homeowner's Association, to assess if measures could be put in place to officially recognize the protection needed for Glen Springs (USFWS, 2022)

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SPECIES ACCOUNT: *Etheostoma osburni* (Candy darter)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

Candy darters are small (55–86 millimeters (mm) standard length (SL; the length measured from the tip of the snout to the last vertebra, which excludes the length of the caudal fin (tail)) (2.2–3.4 inches (in)), freshwater fish that tend to occupy the riffle (i.e., shallow areas of fast, turbulent flow) bottoms of fast moving, cool or cold water streams (Hubbs and Trautman 1932, p. 35; Jenkins and Burkhead 1993, p. 827). Males are very brightly colored, especially during the breeding season (figure 4). The species can be identified by 5 distinctive black saddles on its back and 9 to 11 vertical blue-green bars alternating with narrow bright red-orange bars along its sides. The females maintain a similar general pattern, but the colors are much more subdued, appearing a general olive hue overall (West Virginia Division of Natural Resources (WVDNR) undated factsheet) (USFWS, 2018a).

Taxonomy

The candy darter (previously the “finescale saddled darter”) (Etheostoma osburni) belongs to the Percidae (true perches) family of fishes and was first described by Hubbs and Trautman (1932, entire) from a specimen collected in 1931 from Stony Creek, a tributary of the Greenbrier River in Pocahontas County, West Virginia. Other specimens used to describe the species were collected in 1885 and 1931 from Reed Creek, a tributary of the New River in Wythe County, Virginia (Hubbs and Trautman 1932, pp. 34–35). The candy darter is recognized by the American Fisheries Society (Page et al. 2013, p. 139) as a valid taxon and is listed as such in the Integrated Taxonomic Information System (ITIS) database (http://www.itis.gov) (accessed October 13, 2016). We have no information to suggest there is scientific disagreement about the candy darter’s taxonomy (USFWS, 2018a).

Historical Range

The best available information supports that the candy darter is endemic to the upper Kanawha River basin. Records dating back to 1885 indicate that the historical range of the candy darter is limited to the Gauley and greater New River watersheds in West Virginia and Virginia (but not extending into the New River watershed in North Carolina) (see figures 2 and 6) (Hubbs and Trautman 1932, entire; Addair 1944, pp. 170–172; Burton and Odum 1945, pp. 191–192; Hocutt et al. 1978, pp. 61–64; Hocutt et al. 1979, 63–74; Chipps et al. 1993, pp. 52–54; Jenkins and Burkhead 1993, pp. 827–830; Stauffer et al. 1995, pp. 308–309, Helfrich et al. 1996, entire; Bye 1997, entire; Welsh et al. 2006, pp. 14–16, 22, 25). The first documented candy darter specimen was collected from South Fork Reed Creek in the Upper New River watershed of Virginia in 1885; however, the specimen was not identified until the species was formally described by Hubbs and Trautman in 1932 (p. 35). The holotype (the single specimen on which Hubbs and Trautman based the species’ description) was collected from Stony Creek in the Greenbrier River watershed of West Virginia by Addair in 1931 (Hubbs and Trautman 1932, pp. 34–35). Subsequent fish surveys of the region documented candy darters in other upper Kanawha basin tributary watersheds, including the Gauley and Middle New River (which includes the Bluestone) watersheds (Addair 1944, pp. 170–172; Burton and Odum 1945, pp. 191–192; Hocutt et al. 1978, pp. 61–64; Hocutt et al. 1979, 63–74; Chipps et al. 52–54; 1993; Jenkins and Burkhead

1993, pp. 827–830; Jenkins and Kopia 1995, pp. 6–11; Stauffer et al. 1995, pp. 308– 309, Helfrich et al. 1996, entire; Bye 1997, entire; Welsh et al. 2006, pp. 14–16, 22, 25). A single 1972 report of a candy darter in the Elk River below the Kanawha Falls was not confirmed and is considered dubious (Hocutt et al. 1979, p. 63). There are no other historical or recent reports of the species from below Kanawha Falls. The candy darter is not confirmed to occur in the Lower New River watershed; however, the best available data suggest that the species did likely occupy this watershed. Jenkins and Kopia (1995, pp. 7–8) reported that Lower New River fish collections from 1964 and 1991 may have produced candy darters, but the specimens were never confirmed. Because the Lower New River watershed is geographically positioned between the Middle New and Greenbrier River watersheds (upstream) and the Gauley River watershed (downstream), each of which have confirmed candy darter populations and suitable habitat, it is reasonable to conclude that the species likely occurred in the Lower New River watershed. Support that the Lower New River watershed was historically occupied by the candy darter is provided by the expansion of the variegate darter within this watershed and other connected candy darter habitats. The variegate darter is a closely related species with similar life history characteristics and habitat requirements as the candy darter (Jenkins and Burkhead 1993, pp. 824, 828–829; Stauffer et al. 1995, pp. 308–309, 315; Kuehne and Barbour 2015, pp. 66–67, 80–81, 86–87). Since its introduction above Kanawha Falls in the late 20th century, the variegate darter has colonized the Lower New River watershed, along with known candy darter streams in the lower Gauley and Greenbrier River watersheds (Wellman 2004, p. 10; WVDNR 2016, unpublished data; Switzer et al. 2007, entire; Gibson 2017, entire). Because the variegate darter and candy darter share general habitat requirements, this pattern of variegate darter expansion suggests that the Lower New River watershed likely maintains habitat conditions also suitable for the candy darter. Additionally, genetic analysis of phenotypical variegate darters collected from three Lower New River tributaries (Glade Creek, Manns Creek, and Laurel Creek) between 2004 and 2006 confirmed the presence of candy darter alleles in these populations (Switzer 2004, pp. 93, 111; Switzer et al. 2007, pp. 28, 33). These candy darter genetic markers could have been introduced into the Lower New watershed via the movement of individual candy darters or hybrids from the Greenbrier watershed or they could be a remnant of resident New River candy darters that were subsequently extirpated by genetic swamping after variegate darters were introduced. This line of evidence (the report of candy darter specimens in 1964 and 1991, the historical connectedness of the Lower New River watershed to known candy darter populations, and the apparent availability of suitable habitat) leads us to conclude that the Lower New River watershed represents a historical candy darter metapopulation. Although the available survey data appear to indicate the candy darter was always patchily distributed and perhaps rare within most of its historical range, it is important to consider that by the time of the earliest candy darter records (Addair 1944, p. 171), the species had likely already undergone a significant reduction in distribution and numbers (Jenkins and Kopia 1995, pp. 2, 11–12; Dunn 2013, p. 19; Dunn and Angermeier 2016, p. 1267). While early (pre-1900) survey data are sparse, fishery experts agree that by the late 1800s overall fish populations in the region had already undergone severe declines as a result of widespread aquatic habitat degradation (e.g., sedimentation, increased temperatures, chemical toxicity) caused by unregulated, industrial-scale logging, agriculture, coal mining, and sewage and chemical discharges (Ayres and Ashe 1905, pp. 17–23, 73–77; Goldsborough and Clark 1907, pp. 31–33; Addair 1944, pp. 7–9, 201–202, 205; Hocutt et al. 1978, p. 75; Eller 1982, pp. 93–112; Dolloff 1994, pp. 121–122; Messinger and Chambers 2001, p. 6). Several contemporaneous scientific accounts from within known candy darter areas describe habitat conditions and provide information on overall fish abundance during this period. In 1888, Reed Creek (from which the first known candy darter specimen had been collected 3 years previously) was described as a warm, muddy stream flowing through cultivated fields and pastures (Jordan 1889, p. 140). In 1900, researchers concluded that in West Virginia “the aquatic life in general, and fishes in particular, had been and are now in many streams being greatly injured and in others practically destroyed by the unwise and destructive operations of the lumberman and the miner” (Goldsborough and Clark 1907, p. 31). While Goldsborough and Clark (1907, pp. 31–32) reported that fish were still abundant in many of the less disturbed headwater streams of the Greenbrier River, they concluded that fish in the lower Greenbrier and New River tributaries had suffered severe declines. In the Bluestone River, Goldsborough and Clark (1907, pp. 31–32) noted that coal mining operations in the upper watershed had “greatly reduced” fish throughout nearly the entire river. Therefore, by the time researchers first began documenting the candy darter in the 1930s, the abundance and distribution of the species had likely been significantly reduced as a result of widespread habitat degradation. The factors supporting the candy darter having been more abundant and widely distributed within its range than indicated by post industrialization surveys include: (1) the geographical distribution and historical connectedness of known candy darter streams; (2) the diversity of habitat conditions (e.g., stream size, gradient, and water temperatures) associated with all known candy darter occurrences (Stauffer et al. 1976, p. 16; Jenkins and Kopia 1995, pp. 5–6; Dunn 2013, pp. 24–26; Dunn and Angermeier 2016, p. 1267); (3) high candy darter abundance and continuity documented in some streams with high quality habitat (Chipps et al. 1993, p. 52; Leftwich et al. 1996, pp. 8–9); and (4) severe degradation of aquatic habitat conditions and declines in fish abundance prior to comprehensive fish surveys. Together these factors support the conclusion that the candy darter was likely more widely distributed and abundant throughout its historical range where suitable habitat (described above) existed (USFWS, 2018a).

Current Range

VA, WV; The best available data indicate that the candy darter has been extirpated from the Bluestone and Lower New River watersheds, but that the species continues to occupy areas in the Upper Gauley, Lower Gauley, Greenbrier, Middle New, and Upper New River watersheds (figure 9 and Appendix A) (Jenkins and Burkhead 1994, p. 829; Welsh et al. 2006, p. 43; Switzer et al. 2007, pp. 3, 12, 22–24; Dunn 2013, p. 23; WVDNR 2016, unpublished data). These data indicate that, of 35 known candy darter populations, 17 have been extirpated, and many of the remaining populations are small and/or isolated from each other by physical barriers or long reaches of unoccupied (and possibly unsuitable) habitat (e.g., Stony, Walker, Wolf, and Cripple Creeks in the Middle and Upper New River watersheds and the Lower Gauley population below the Summersville Dam). The most abundant candy darter populations occur in the Upper Gauley and upper Greenbrier River watersheds, and in Stony Creek in the Middle New River watershed (Dunn 2013, p. 10; McBaine 2016, unpublished data). However, the distribution of candy darters in the Greenbrier River watershed has and is changing rapidly as variegate darters expand their range (Switzer et al. 2007, pp. 3–6, 22–25; Gibson 2017, p. 19), which is discussed further in the following chapters (USFWS, 2018a).

Critical Habitat Designated

Yes; 5/7/2021.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), designate critical habitat for the candy darter (Etheostoma osburni) under the Endangered Species Act (Act). In total, approximately 593 stream kilometers (368 stream miles) in Virginia and West Virginia fall within the boundaries of the critical habitat designation. The effect of this final rule is to designate critical habitat under the Act for the candy darter, an endangered species of fish. (USFWS, 2021)

Primary Constituent Elements/Physical or Biological Features

(1) Critical habitat units are depicted for Bland, Giles, and Wythe Counties, Virginia, and Greenbrier, Nicholas, Pocahontas, and Webster Counties, West Virginia, on the maps in this entry. (2) Within these areas, the physical or biological features essential to the conservation of the candy darter consist of the following components: (i) Ratios or densities of nonnative species that allow for maintaining populations of candy darters. (ii) A blend of unembedded gravel and cobble that allows for normal breeding, feeding, and sheltering behavior. (iii) Adequate water quality characterized by seasonally moderated temperatures and physical and chemical parameters (e.g., pH, dissolved oxygen levels, turbidity) that support normal behavior, growth, and viability of all life stages of the candy darter. (iv) An abundant, diverse benthic macroinvertebrate community (e.g., mayfly nymphs, midge larvae, caddisfly larvae) that allows for normal feeding behavior. (v) Sufficient water quantity and velocities that support normal behavior, growth, and viability of all life stages of the candy darter. (3) Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on May 7, 2021. (4) Critical habitat map units. The provided maps were made using the geographic projection GCS_North_ American_1983 coordinate system. Four spatial layers are included as background layers. We used two political boundary layers indicating the State and county boundaries within the United States available through ArcMap Version 10.5 software by ESRI. The roads layer displays major interstates, U.S. highways, State highways, and county roads in the Census 2000/ TIGER/Line dataset provided by the U.S. Census Bureau, and available through ArcMap Version 10.5 software. Lastly, the hydrologic data used to indicate river and stream location are a spatial layer of rivers, streams, and small tributaries from the National Hydrology Database (NHD) Plus Version 2 database. This database divides the United States into a number of zones, and the zones that include the area where candy darter critical habitat is indicated are the Ohio-05 hydrologic zone and the Mid Atlantic-02 hydrologic zone. The maps provided display the critical habitat in relation to State and county boundaries, major roads and highways, and connections to certain rivers and streams within the larger river network. The maps in this entry, as modified by any accompanying regulatory text, establish the boundaries of the critical habitat designation. The coordinates or plot points or both on which each map is based are available to the public at https://www.fws.gov/ northeast/candydarter/, at http:// www.regulations.gov at Docket No. FWS–R5–ES–2018–0050, and at the field office responsible for this designation. You may obtain field office location information by contacting one of the Service regional offices, the addresses of which are listed at 50 CFR 2.2. (USFWS, 2021)

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features that are essential to the conservation of the species and which may require special management considerations or protection. The overall habitat characteristics that are important for the candy darter include sufficiently stabilized forest streambanks throughout the watersheds such that water quality allows for normal feeding, breeding, and sheltering in an area with sufficiently low numbers of nonnative species (Service 2018, pp. 15–17, 22–25, 32–34). The features essential to the conservation of the candy darter may require special management considerations or protections to reduce the following threats: (1) Hybridization with the nonnative variegate darter; (2) general increase in water temperature, primarily attributed to land use changes; (3) changes in water chemistry, including, but not limited to, changes in pH levels or concentrations of certain contaminants (such as, but not limited to, coliform bacteria); (4) habitat fragmentation primarily due to construction of barriers and impoundments; (5) excessive sedimentation and stream bottom embeddedness (the degree to which gravel, cobble, rocks, and boulders are surrounded by, or covered with, fine sediment particles); and (6) competition for habitat and other instream resources and predation from nonnative fishes. Management activities that could ameliorate these threats include, but are not limited to: (1) Use of BMPs designed to reduce sedimentation, erosion, and bankside destruction; (2) protection of riparian corridors and retention of sufficient canopy cover along streambanks; (3) reduction of other watershed disturbances that release sediments, pollutants, or nutrients into the water; (4) public outreach requesting the public's assistance with stopping the movement of nonnative aquatic species; (5) increased enforcement and/or outreach regarding existing regulations prohibiting the movement of bait fish; (6) survey and monitoring to further characterize the extent and spread of hybridization with variegate darters; (7) research to determine whether some environmental factors or set of factors might allow candy darters to persist in particular areas despite variegate darter introductions; (8) research characterizing habitat conditions in historically extirpated candy darter sites to facilitate successful reintroduction efforts; (9) research and development of tools and techniques that can be used to address the competitive behavior that allows for variegate darters to dominate candy darters, which leads to hybridization; and (10) reintroductions of candy darters to historically extirpated areas and/or population augmentation of candy darters in sufficient numbers to outcompete variegate darters. (USFWS, 2021)

Life History

Reproduction Narrative

Adult: Candy darters spawn in mid- to late spring, approximately late April through June (Kuehne and Barbour 2015, p. 80) and are classified as brood-hiding, benthic spawners (Jenkins and Kopia 1995, pp. 4–5). Female candy darters select patches of finer substrates (i.e., pebble and gravel) situated among larger cobble and boulder substrates in riffles and swift runs to deposit eggs (Jenkins and Kopia 1995, pp. 4–5), and males simultaneously deposit sperm to fertilize the eggs as they are deposited in the substrate (Jenkins and Kopia 1995, pp. 4–5). One species expert observed that female candy darters may lay multiple clutches of eggs (Dunn 2017, pers. comm.). During spawning, males become aggressively territorial, as evidenced by observations of torn fins and other signs of aggression following the breeding season (Jenkins and Burkhead 1993, p. 828). Helfrich et al. (1996, p. 4) observed spawning pairs interrupted by a third large male, after which the two males would chase and nip at each other until one was driven away; in all observed instances of spawning aggression, the larger male prevailed. Schoolcraft et al. (2002, p. 6) observed that females had a relatively low number of mature ova (average 170 per individual), and analysis showed no significant deviation from 1:1 sex ratios. Time to hatching for fertilized eggs is not reliably described for candy darters, but for most Etheostoma species, incubation time lasts approximately 5 to 25 days, with variations based largely on water temperature (Hubbs et al. 1969, p. 184; Burr and Page 1979, p. 9). Newly hatched individuals are considered "young-of-year" until age 1, when total length (TL; the length measured from the tip of the snout to the end of the tail) is ~45 mm (1.8 in). They are then considered juveniles until females reach a TL greater than 60 mm (2.4 in) and males a TL greater than 65 mm (2.6 in), at which point they are considered adults (USFWS, 2018a).

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2018a)

Habitat Narrative

Adult: The candy darter is known from 2nd order and larger (generally wider than about 3.7 m (12 ft)) streams and rivers (including the mainstem of the New River) and is described as a habitat specialist, being most often associated with faster flowing stream segments with coarse bottom substrate (e.g., gravel, cobble, rocks, and boulders) and low levels of siltation (Addair 1944, p. 170; Jenkins and Burkhead 1993, pp. 828–829; Chipps et al. 1994, entire; Jenkins and Kopia 1995, pp. 5–6; Leftwich et al. 1996, pp. 6–12; Dunn 2013, pp. 16–17, 23–24; Dunn and Angermeier 2016, pp. 1267, 1272–1273). In streams maintaining favorable habitat conditions, including abundant coarse bottom substrate, candy darters can occur throughout the stream continuum in relatively high numbers. For example, a survey of Stony Creek (a rocky, cool or cold water trout stream that flows into the New River) (figure 8) found candy darters in 74 percent of the habitat units sampled (n = 942) throughout the 13.8-stream kilometer (skm) (8.6-stream mile (smi)) survey reach (Leftwich et al. 1996, pp. 7–12). Candy darters were observed in all stream habitat types (82 percent of riffles, 90 percent of runs, 79 percent of glides, and 41 percent of pools) with densities ranging from 0 to 30 candy darters per 100 square meters (CD/100 m2) (0 to 2.79 CD/100 square feet (ft2)). The highest densities were found in riffles, with an average of 10 CD/100 m2 (0.93 CD/100 ft2) (Leftwich et al. 1996, pp. 7–12). Studies have also noted that adult candy darters are often observed near rock cover (Chipps et al. 1994, p. 131; Jenkins and Kopia 1995, pp. 5–6) and may overwinter under the cover of rocks or woody debris in deeper water habitats (Leftwich et al. 1996, p. 6). Candy darters appear to prefer shallower (depths less than 50 centimeters (cm) (19.7 in) and at least moderately flowing (velocities greater than19 centimeters/second (cm/s) (7.5 in/s) waters, with individual darters partitioning within stream microhabitat by age class (Chipps et al. 1994, entire; Helfrich et al. 1996, pp. 2–3; Dunn 2013, pp. 23–24; Dunn and Angermeier 2016, pp. 1272–1273). Observations of candy darter microhabitat use in the spring and fall of 2011 found that adults selected areas with faster flowing waters (greater than 120 cm/s (47.2 in/s) in the spring; greater than 60 cm/s (23.6 in/s) in the fall), juveniles selected intermediate velocities (40 to 120 cm/s (15.7 to 47.2 in/s)), and first year fish selected slower flowing areas (0 to 80 cm/s (0 to 31.5 in/s)) (Dunn and Angermeier 2016, pp. 1272–1273). This pattern of habitat partitioning by life stage has been noted by other researchers (Jenkins and Kopia 1995, pp. 5–6). Suitable candy darter habitat is also characterized by low levels of siltation and stream bottom embeddedness (the degree to which gravel, cobble, and boulders are surrounded by, or covered with, fine sediment particles) (Jenkins and Kopia 1995, pp. 5–6; Dunn and Angermeier 2016, entire). In 1991, researchers surveyed for the species at 22 locations in 10 streams in the upper Gauley and Greenbrier River watersheds and concluded that excessive siltation characterized areas where the species had declined or was absent (Chipps et al. 1993, p. 52). Dunn and Angermeier (2016, entire) observed candy darter microhabitat use in three occupied streams (one each in the Gauley, Greenbrier, and New River watersheds) and found that, in general, individuals selected sites with less than 26-percent silt cover and substrate embeddedness. The researchers also noted differences in microhabitat selection based on life stage. Adult candy darters almost completely avoided areas where silt cover and embeddedness were greater than 25 percent, while younger individuals were less averse to areas with fine sediments (Dunn and Angermeier 2016, p. 1273). Of the habitat variables examined in the study (depth, velocity, substrate, embeddedness, and silt cover), embeddedness was consistently the most important parameter determining individual candy darter microhabitat selection (regardless of life stage) and overall population robustness (Dunn and Angermeier 2016, p. 1275). Based on candy darter occurrence records from cold, cool, and warm water streams, the species is probably best described as eurythermal (i.e., able to tolerate a wide range of water temperatures). In 2012, Dunn (2013, pp.18–28) surveyed 43 sites within the historical range of the candy darter and determined that sites where candy darters were present had cooler daily temperatures in all seasons, as well as a greater range of annual and daily temperatures, than sites not harboring the species. In the summer, sites with candy darters had average maximum temperatures of 27.8 degrees Celsius (ºC) (82.0 degrees Fahrenheit (ºF)), with three candy darter sites having maximum summer temperatures over 30.0 ºC (86.0 ºF). In the winter, the candy darter sites had average minimum temperatures of 0.2 ºC (32.4 ºF). Between 1973 and 1974, Stauffer et al. (1976, pp. 8–9, 16) collected two candy darters from the New River near Glen Lyn, Virginia. One capture site was in an area where ambient water temperatures ranged from approximately 5 ºC to 25 ºC (41 ºF to 77 ºF), depending on the month. The other capture site was influenced by the heated discharge from an electrical power plant where monthly water temperatures were calculated to be higher, ranging from approximately 11 ºC to 32 ºC (52 ºF to 90 ºF), seasonally. Jenkins and Kopia (1995, pp. 5–6) commented on these records and reported the water temperatures where these specimens were captured to be 22.2 ºC to 27.8 ºC (72.0 ºF to 82.0 ºF). While the known distribution and abundance of the candy darter seems to indicate that cool or cold “trout” streams (e.g., the headwaters of the Gauley and Greenbrier Rivers, Stony Creek) are preferred habitat, data suggest that if the habitat is otherwise favorable for the species (e.g., abundant rocky, unembedded bottom substrate) warm water streams may also be suitable for the species (Dunn 2013, pp. 24–26) (USFWS, 2018a).

Dispersal/Migration

Motility/Mobility

Adult: High

Dispersal/Migration Narrative

Adult: No information exists characterizing the movement patterns of candy darters among suitable habitat patches (Dunn and Angermeier 2016, p. 1278). The scientific literature suggests that many other small-bodied, riffle-dwelling fish species complete their lifecycle within single riffles or riffle complexes spanning just a few hundred meters (Hill and Grossman 1987, pp. 377–378; Roberts and Angermeier 2007, p. 422); however, some darter species have been documented moving upstream and downstream between riffles and between riffles and pools, with within-year movements generally ranging from 36 to 420 meters (m) (118 to 1,378 feet (ft)), but with some movements of up to 4.8 km (3.0 mi) (May 1969, pp. 86–87, 91; Freeman 1995, p. 363; Roberts and Angermeier 2007, pp. 422, 424–427). Longer migratory movements are suggested for other darter species. The bluebreast darter (Etheostoma camurum), a species that inhabits moderate- to large-sized streams and is typically found in riffles, similar to the candy darter, were found to be well-distributed throughout a 51-km (32-mi) reach of river during the breeding season (Trautman 1981, pp. 673–675). However, from September to early spring, the bluebreast darter’s numbers appeared to shift from the upper half of the reach to the lower half of the reach (Trautman 1981, pp. 673–675). Individual bluebreast darters captured in the spring were documented to have moved 152 m (500 ft) in a single day. The author concluded that bluebreast and other darter species migrated upstream in spring and downstream in the fall (Trautman 1981, pp. 673–675). We are uncertain if similar long distance, seasonally mediated movements are significant to the candy darter (USFWS, 2018a).

Population Information and Trends

Resiliency:

In summary, the candy darter has been extirpated from almost half of its historical range; 17 (49 percent) of 35 known populations (and 2 (29 percent) of 7 known metapopulations), with the extirpations representing a complete loss of resiliency in those populations. Of the 18 extant populations, 5 (28 percent) have a current score of high or moderate to high resiliency, 9 (50 percent) have moderate resiliency, and 4 (22 percent) have low or moderate to low resiliency. The five populations with higher resiliency scores occur in three metapopulations (the Upper Gauley in the Appalachian Plateaus physiographic province and the Greenbrier and Middle New in the Valley and Ridge physiographic province); the remaining two extant metapopulations (the Lower Gauley in the Appalachian Plateaus physiographic province and the Upper New River in the Valley and Ridge physiographic province) maintain populations with moderate and low resiliency. Therefore, we conclude the candy darter currently maintains moderate resiliency (USFWS, 2018a).

Representation:

Although the candy darter retains representation in both of the Appalachian Plateaus and Valley and Ridge physiographic provinces, the species has a different distribution than it had historically (e.g., its presence or absence in headwater vs. tributary streams), and likely a different ability to respond to stochastic and catastrophic events, thereby putting the species at increased risk of extinction from any such events. Therefore, because candy darter populations are no longer found in the lower mainstem rivers and tributaries, we conclude that the species' representation is moderate to low (USFWS, 2018) (USFWS, 2018a).

Redundancy:

Redundancy describes the ability of a species to withstand catastrophic events by maintaining multiple, resilient populations distributed (and connected) within the species' ecological settings and across the species' range. We assessed candy darter redundancy at two scales, within the individual metapopulations and across all of the metapopulations. Candy darters currently occur in five (71 percent) of seven known metapopulations. The Upper Gauley metapopulation maintains six (100 percent) of six presumably well-connected candy darter populations, two of which have high or high to moderate resiliency. Therefore we conclude that this metapopulation has moderate internal redundancy. The Greenbrier metapopulation maintains 7 (58 percent) of 12 moderately to well-connected populations, 2 of which are highly resilient. Therefore we conclude that the Greenbrier metapopulation has moderate internal redundancy. In the Middle New metapopulation, the species occurs in three populations that are separated from each other by considerable distances (55 to 135 skm (34 to 84 smi)), which makes it unlikely they maintain significant, if any, connectivity. One of these populations has moderate resiliency and the other two have low resiliency, therefore we conclude that the Middle New metapopulation has low internal redundancy. In the Lower Gauley and Upper New metapopulations, candy darters are limited to a single population in each; therefore these two metapopulations have no internal redundancy. Candy darters have been extirpated from the Bluestone and presumably the Lower New metapopulations, therefore they offer no redundancy to the species. Based on the species' current distribution across its historical range (5 (71 percent) of 7 known metapopulations and 18 (51 percent) of 35 known populations) and the species' distribution and condition within each of the seven metapopulations (2 with moderate internal redundancy, 1 with low internal redundancy, and 2 with no internal redundancy), we conclude that the candy darter's current redundancy is low (USFWS, 2018a).

Threats and Stressors

Stressor: Hybridization
Exposure:
Response:
Consequence:
Narrative: During an informational meeting of candy darter experts and land managers from the Virginia Department of Game and Inland Fisheries (VDGIF), the West Virginia Division of Natural Resources (WVDNR), the U.S. Geological Survey (USGS), the National Park Service (NPS), the U.S. Forest Service (USFS), and the Virginia Polytechnic Institute (VPI) ranked hybridization (the interbreeding of individuals from different taxa) as the primary stressor affecting the candy darter's viability (Service 2016). Hybridization is relatively common in freshwater fishes and has been documented in many darter species, under both natural conditions and following human interference (Keck and Near 2009, entire). It is important to note that hybridization is considered particularly problematic in situations where non-native species are introduced into areas outside of their natural ranges (Allendorf et al. 2001, entire; Todesco et al. 2016, entire). As discussed previously, the variegate darter, a closely related species to the candy darter, was historically precluded from the upper Kanawha River basin by the Kanawha Falls at Glen Ferris, West Virginia. However, by the late 20th century, variegate darters were established in the upper Kanawha basin, likely as a result of human-mediated "bait-bucket" transfer (Switzer et al. 2007, p. 4; Service 2016). Bait bucket transfers occur when anglers or commercial bait sellers collect species of live baitfish indigenous to one watershed and transport them for use in watersheds where they may not be native. Often these baitfish escape or are intentionally released in the new watershed and, under certain conditions, can establish new reproducing populations (Ludwig and Leitch 1996, entire). Candy darters and variegate darters have similar life histories, are similarly sized, share general habitat requirements, and are not subject to any known physiological or behavioral barriers to reproduction (Hubbs and Trautman 1932, pp. 33– 34; Switzer et al. 2007, pp. 3–6). Therefore, once variegate darters were established in the upper Kanawha basin, the interbreeding of the two species was likely inevitable (figure 12) (USFWS, 2018a).

Stressor: Sedimentation
Exposure:
Response:
Consequence:
Narrative: Excessive stream sedimentation (or siltation) results from soil erosion associated with upland activities (e.g., agriculture, forestry, mining, unpaved roads, road or pipeline construction, and general urbanization) as well as activities that can destabilize stream channels themselves (e.g., dredging or channelization, construction of dams, culverts, pipeline crossings, or other instream structures) (West Virginia Department of Environmental Protection (WVDEP) 2012, p.12). Excessive sediments can cover the stream bottom and fill the interstitial spaces between bottom substrate particles (i.e., sand, gravel, and cobbles) and in severe cases also cause stream bottoms to become "embedded," in which case substrate features including larger cobbles, rocks, and boulders are surrounded by, or buried in, sediment. This can affect fish species directly

by limiting sheltering or breeding habitat and/or by causing shifts in the benthic community structure that alters the prey base (Berkman and Rabeni 1987, 291–293; Chambers and Messinger 2001, p. 50–51; Sutherland et al. 2002, entire; McGinley et al. 2013, pp. 223–226) (USFWS, 2018a).

Stressor: Water temperatire
Exposure:
Response:
Consequence:
Narrative:

Recovery

Reclassification Criteria:
Recovery Priority Number 5 (USFWS, 2018b)

Recovery Actions:

- Interim Recovery Strategy: To ensure long term viability of the candy darter, we need to increase the redundancy, resiliency, and representation of the species. In order to achieve this, an Interim Recovery Strategy has been developed that has five approaches: 1. Maintain extant populations by conserving the genetic diversity and physical and biological features on the landscape that are essential for the species' conservation. 2. Minimize the risk of variegate darter introductions or spread in areas with little evidence of introgression. 3. Investigate factors that would minimize and control hybridization, and implement those measures in currently occupied areas that are affected by ongoing hybridization. 4. Repatriate candy darters to historically occupied areas where variegate darters are not present. 5. Investigate feasible methods to remove variegate darters and repatriate candy darters (USFWS, 2018b).

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SPECIES ACCOUNT: *Etheostoma percnurum* (Duskytail darter)

Species Taxonomic and Listing Information

Listing Status: Experimental Population, Non-Essential; 04/27/1993, 08/12/2002, 10/15/2007 ; Southeast Region (R4) (USFWS, 2016)

Physical Description

A small fish (6.4 cm) with a straw to olivaceous colored body, a medium to dark grey top of the head, and a dingy white to pale gray belly. It has 10 to 15 long dark vertical bars on the sides of its body, 38 to 48 lateral scales, and 17 to 20 dorsal spines and rays (USFWS, 1993).

Taxonomy

Etheostoma lemniscatum, E. marmorpinnum, and E. sitikuense formerly were included in E. percnurum; these were described as distinct species by Blanton and Jenkins (2008). (NatureServe, 2015)

Historical Range

The duskytail darter was historically located in the Little River, Citico Creek, BSF, Copper Creek, Clinch River, Abrams Creek, and South Fork Holston River (USFWS, 2012).

Current Range

The duskytail darter is currently restricted to 19 rkm (12 rmi) of the Copper Creek tributary to the Clinch River in Scott County, Tennessee (Rakes et al. 2009) (USFWS, 2012).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Adults and immatures are benthic invertivores (NatureServe, 2015). The youngest individuals consume microcrustaceans, chironomid larvae, and heptageniid nymphs, while larger individuals are mainly benthic insectivores. Heptageniids were the dominant food item in the three largest size classes (Layman 1991). Large individuals sometimes eat fish eggs (USFWS, 1993)

Reproduction Narrative

Adult: In Copper Creek over several years, this species spawned from mid-April to mid-June (Jenkins and Burkhead 1994); most spawning apparently occurred in May (Burkhead and Jenkins 1991). Males guard eggs. Based on related species, individual females lay probably multiple clutches each season (Layman 1991) (clutches separated by intervals of several days). Individuals live a little more than two years at most.; This species may compete with E. flabellare in the overlap zone in Cooper Creek, Virginia (Burkhead and Jenkins 1991) (NatureServe, 2015). Prior to the spawning act, the male chooses and cleans a site under a rock. Eggs are deposited individually into a cluster on the underside of the nest rock (Layman 1984a). Males may spawn with multiple females, resulting in a clutch size of 23 to 150 eggs. After several days, the famel can spawn with other males. Duskytail darters can spawn as 1 year olds (USFWS, 1993).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015; sea dispersal/migration narrative)

Habitat Narrative

Adult: Habitat includes gravel, rubble, and slabrock pools and runs of small to medium rivers (Page and Burr 2011); the "lower main channel of Copper Creek, which is a clear, warm, moderate-gradient, intermontane stream in the Ridge and Valley Province of Virginia. Adults occur primarily in pools, and much less frequently in swift runs, and are associated with relatively clean gravel, cobble, and boulders. The range of habitats includes slack water, detritus, slightly silted stones, and bedrock" (Jenkins and Burkhead 1994, Blanton and Jenkins 2008). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Not available (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Data on dispersal and other movements generally are not available (NatureServe, 2015).

Population Information and Trends

Population Trends:

decreasing/stable depending on population (USFWS, 2021)

Number of Populations:

4 Natural. 2 Reintroduced (USFWS, 2021)

Population Size:

Unknown (USFWS, 2021)

Population Narrative:

The duskytail darter populations in the Little River (marbled darter), Citico Creek (Citico darter), and Big South Fork (tuxedo darter) appear to be stable. Populations were reintroduced into Abrams Creek (Citico darter) and Tellico River (Citico darter) that also appears to be reproducing and stable. However, the duskytail darter has shown a marked decrease in both number of known sites and abundance in Copper Creek since 2008. In Copper Creek the species' range has declined to 14.5 river km (9 mi) and it is now restricted to only 2 of 10 historical sites (CFI 2018). Overall the complex occurs in 80.9 km (50.3 mi) of river, with 14.5 km (9 mi) associated with the marbled darter, 13.3 km (8.3 mi) the Citico darter, 38.6 km (24 mi) the tuxedo darter, and 14.5 km (9 mi) the duskytail darter. Based on ongoing threats associated with coal mining, oil and gas exploration, agriculture, recreational activities, restricted range/small population size, and the species decline in Copper Creek, the duskytail darter continues to be in danger of extinction throughout their range. Therefore, the status of the duskytail darter should remain as endangered. (USFWS, 2021)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Physical habitat destruction resulting from a variety of human-induced impacts such as siltation, disturbance of riparian corridors, and changes in channel morphology continues to plague the Tennessee and Cumberland River systems. The most significant of these impacts is siltation caused by excessive releases of sediment from activities such as agriculture, resource extraction (e.g., coal mining, silviculture), road construction, and urban development (Waters 1995). Wood and Armitage (1997) identified at least five impacts of sedimentation on fish, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency. Pollutants entering the Tennessee and Cumberland River systems may include sediments, fertilizers, herbicides, pesticides, animal wastes, pharmaceuticals, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streams such that the habitat and food sources for species like the duskytail darter are negatively impacted. Common land uses within the Clinch-Powell watershed include urban, industrial, commercial, and residential development; livestock production; agricultural cropping including tobacco and corn; coal mining, reclaimed coal mined lands, and "abandoned" coal mined lands (i.e., lands affected by mining prior to the federal law that were not reclaimed properly); road and railroad networks; and silvicultural practices (US EPA 2002). These land use activities act as sources of stress to the duskytail darter by contributing sediment and contaminants into the watershed (USFWS, 2012).

Stressor: Stochastic events (USFWS, 2012)
Exposure:
Response:
Consequence:

Narrative: The duskytail darter has a limited geographic range and small population size, leaving the species extremely vulnerable to localized extinctions from accidental toxic chemical spills or other stochastic disturbances and to decreased fitness from reduced genetic diversity. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007) (USFWS, 2012).

Recovery

Reclassification Criteria:
1. Three distinct viable populations exist, through protection and enhancement of the existing populations in the Little River, Blount County, Tennessee; Citico Creek, Monroe County, Tennessee; Big South Fork of the Cumberland River, Scott County, Tennessee; and Copper Creek and Clinch River, Scott County, Virginia, and successful establishment of a reintroduced population in Abrams Creek or other historic habitat or the discovery of an additional population (USFWS, 2012).

2. Studies of the fish's biological and ecological requirements have been completed and the implementation of management strategies developed from these studies has been or is likely to be successful (USFWS, 2012).

3. No foreseeable threats exist that would likely threaten the survival of any of the three aforementioned populations (USFWS, 2012).

Delisting Criteria:
1. Through protection and enhancement of the existing population and successful establishment of reintroduced populations or the discovery of additional populations, five distinct viable populations exist (USFWS, 2012).

2. Studies of the fish's biological and ecological requirements have been completed and the implementation of management strategies developed from these studies has been successful (USFWS, 2012).

3. No foreseeable threats exist that would likely threaten the survival of any of the populations (USFWS, 2012).

Recovery Actions:
- Utilize existing legislation/regulations to protect the species (USFWS, 1993).
- Search for new populations (USFWS, 1993).
- Monitor existing populations (USFWS, 1993).
- Develop and utilize an information/education program (USFWS, 1993).
- Determine the species' life history requirements (USFWS, 1993).
- Determine threats and alleviate those which threaten the species' existence (USFWS, 1993).
- Through reintroduction and protection, establish five viable populations (USFWS, 1993).
- Revise the current Recovery Plan to reflect the current status of the species' knowledge and to add threats based recovery criteria (USFWS, 2012).

- Continue to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations (USFWS, 2012).
- Characterize the species' habitat (relevant physical, biological, and chemical components) for all life history stages (USFWS, 2012).
- Continue to monitor the Clinch River to determine species presence or absence in the river. Conduct within population genetic analyses to determine level of diversity. Consider propagation and reintroduction into the Clinch River. If propagation is found warranted, prepare a propagation plan for the species (USFWS, 2012).
- Continue to utilize existing legislation and regulations (Federal Endangered Species Act, Federal and State surface mining laws, water quality regulations, stream alteration regulations, Federal Energy Regulatory Commission licensing, etc.) to protect the fish and its habitats (USFWS, 2012).
- Continue efforts to reduce non-point source pollution from agricultural activities by working through the Partners for Fish and Wildlife, Farm Bill, and other landowner incentive programs to implement best management practices (USFWS, 2012).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS : Duskytail Darter: • Continue to monitor the Clinch River to determine species presence or absence in the river. • Continue propagation and reintroduction efforts for the duskytail darter. • Investigate additional reintroduction locations. • Continue research on the causes of decline in Copper Creek

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SPECIES ACCOUNT: *Etheostoma phytophilum* (Rush Darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; 9/8/2011; Southeast Region (R4) (USFWS, 2015)

Physical Description

The species reaches an average size of 5 cm (2 in) SL (Bart and Taylor 1999, p. 28; Johnston and Kleiner 2001, p. 3). The brown pigment on the sides of the rush darter is usually not as intense as in the goldstripe darter. Other characteristics of the rush darter are described in Bart and Taylor (1999, p. 28) (USFWS, 2011).

Taxonomy

Formerly included in E. parvipinne (Bart and Taylor 1999) (NatureServe, 2015). Now in the family Percidae, tribe Etheostomatini, and subgenus Fuscatelum (USFWS, 2011).

Historical Range

Historically, rush darters have been found in three distinct watersheds in Alabama: Doe Branch, Wildcat Branch, and Mill Creek of the Clear Creek drainage in Winston County; an unnamed spring run of Beaver Creek and Penny Springs of the Turkey Creek drainage in Jefferson County; and Cove Spring (Little Cove Creek system) and Bristow Creek of the Locust Fork drainage in Etowah County (USFWS, 2011).

Current Range

Range includes the upper Black Warrior River system, Alabama; the species is known from tributaries of Sipsey Fork and Locust Fork (Page and Burr 2011). All populations are above the Fall Line (Warren et al. 2000), in portions of the Cumberland Plateau and Valley and Ridge physiographic provinces (Boschung and Mayden 2004). The species currently occupies tributaries of three watersheds in three counties in Alabama: the Turkey Creek watershed (Jefferson County); the Clear Creek watershed (Winston County); and the Cove Creek watershed (Etowah County) (USFWS 2011). In the Turkey Creek watershed, the species is found in four tributaries including Beaver Creek, an unnamed tributary to Beaver Creek, the Highway 79 site, and Tapawingo or Penny Springs (USFWS 2011). In the Clear Creek watershed (which includes 89 percent of the total range), it is found in Wildcat Branch, Doe Branch, and Mill Creek (USFWS 2011). In the Cove Creek watershed, it has been found in Little Cove Creek, Cove Spring and spring run, and Bristow Creek (USFWS 2011). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 10/16/2012.

Legal Description

On October 16, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Etheostoma susanae (Cumberland darter) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes eight critical habitat units (CHUs) in Alabama (77 FR 63604-63668).

Critical Habitat Designation

The critical habitat designation for Etheostoma susanae includes eight CHUs in Jefferson, Winston, and Etowah Counties in Alabama (77 FR 63604-63668).

Units 1, 2, and 3: Beaver Creek, Unnamed Tributary to Beaver Creek and Highway 79 Spring Site, and Tapawingo or Penny Spring and Spring Run, Jefferson County, Alabama. (i) Unit 1 includes 1.0 river kilometers (rkm) (0.6 river miles (rmi)) of Beaver Creek from the confluence with an unnamed tributary to Beaver Creek, downstream to the confluence with Turkey Creek.

(ii) Unit 2 includes 4.4 rkm (2.7 rmi) of an unnamed tributary of Beaver Creek and two spring runs. The site begins at the section 1 and 2 (T16S, R2W) line, as taken from the U.S. Geological Survey 7.5 topographical map (Pinson quadrangle), downstream to its confluence with Dry Creek, and includes a spring run beginning at the springhead just northwest of Old Pinson Road and intersecting with an unnamed tributary to Beaver Creek on the west side of Highway 79, and a spring associated wetland (0.13 ha, 0.33 ac) within the headwaters, south of Pinson Heights Road, flowing 0.9 km (0.05 mi) from the northwest (33.668173, -86.708577) and adjoining to the Unnamed Tributary (33.667344, -86.707429).

(iii) Unit 3 includes 0.6 rkm (0.4 rmi) of spring run, historically called Tapawingo Plunge, along with 6.7 ha (16.5 ac) of flooded spring basin making up Penny Springs, located south of Turkey Creek, north of Bud Holmes Road, east of Tapawingo Trail Road. The east boundary is at latitude 33° 41' 56.50? N and longitude 86° 39' 55.01? W: 1.0 km (0.6 mi) west of section line 28 and 29 (T15S, R1W) (U.S. Geological Survey 7.5 topographical map (Pinson quadrangle)).

Units 4, 5, and 6: Wildcat Branch, Mill Creek, and Doe Branch, Winston County, Alabama. (i) Unit 4 includes 6.6 rkm (4.1 rmi) of Wildcat Branch from the streams headwaters just east of Winston County Road 29 to the confluence with Clear Creek.

(ii) Unit 5 includes 5.9 rkm (3.7 rmi) of Mill Creek from the streams headwaters just east of Winston County Road 195 to the confluence with Clear Creek.

(iii) Unit 6 includes 4.3 rkm (2.7 rmi) of Doe Branch from the streams headwaters north and west of section line 23 and 14 (R9W, T11S; Popular Springs Quadrangle) to the confluence with Wildcat Branch.

Units 7 and 8: Little Cove Creek, Cove Spring and Spring Run; and Bristow Creek, Etowah County, Alabama. (i) Unit 7 includes 11.2 rkm (6.1 rmi) of Little Cove Creek and the Cove Spring run system along with 5.1 ha (12.7 ac) of the spring run floodplain. Specifically, the Little Cove Creek section (11.0 rkm (6.0 rmi)) is from the intersection of Etowah County Road 179 near the creek headwaters, downstream to its confluence with the Locust Fork River. The Cove Spring and spring run section includes 0.2 rkm (0.1 rmi) of the spring run from the springhead at the West Etowah Water and Fire Authority pumping station on Cove Spring Road to the confluence with Little Cove Creek and includes 5.1 ha (12.7 acres) of the spring run floodplain due south of the pumping facility.

(ii) Unit 8 includes 10.2 rkm (6.3 rmi) of Bristow Creek beginning from the bridge at Fairview Cove Road, downstream to the confluence with the Locust Fork River.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Etheostoma susanae critical habitat consists of five components in Alabama (77 FR 63604-63668):

(i) Springs and spring-fed reaches of geomorphically stable, relatively lowgradient, headwater streams with appropriate habitat (bottom substrates) to maintain essential riffles, runs, and pools; emergent vegetation in shallow water and on the margins of small streams and spring runs; cool, clean, flowing water; and connectivity between spawning, foraging, and resting sites to promote gene flow throughout the species' range.

(ii) Stable bottom substrates consisting of a combination of sand with silt, muck, gravel, or bedrock and adequate emergent vegetation in shallow water on the margins of small permanent and ephemeral streams and spring runs.

(iii) Instream flow with moderate velocity and a continuous daily discharge that allows for a longitudinal connectivity regime inclusive of both surface runoff and groundwater sources (springs and seepages) and exclusive of flushing flows caused by stormwater runoff.

(iv) Water quality with temperature not exceeding 26.7 °C (80 °F), dissolved oxygen 6.0 milligrams or greater per liter (mg/L), turbidity of an average monthly reading of 10 Nephelometric Turbidity Units (NTU; units used to measure sediment discharge) and 15 mg/L total suspended solids (TSS; measured as mg/L of sediment in water) or less; and a specific conductance (ability of water to conduct an electric current, based on dissolved solids in the water) of no greater than 225 micro Siemens per centimeter at 26.7 °C (80 °F).

(v) Prey base of aquatic macroinvertebrates, including midge larvae, mayfly nymphs, blackfly larvae, beetles, and microcrustaceans.

Special Management Considerations or Protections

The eight units we are designating as critical habitat for the rush darter will require some level of management to address the current and future threats to the physical and biological features of the rush darter. None of the critical habitat units (or their corresponding aquifer recharge zones, which are not designated as critical habitat) are presently under special management or protection provided by a legally operative plan or agreement for the conservation of the rush darter. However, 4.7 rkm (2.9 rmi) of the Turkey Creek watershed (Jefferson County) is designated critical habitat for the vermilion darter (Etheostoma chermocki) (75 FR 75913, December 7, 2010) which includes a portion of rush darter unit 2. Various activities in or adjacent to the critical habitat units described in this final rule may affect one or more of the physical and biological features. For example, features in the critical habitat designation may require special management due to threats posed by the following activities or disturbances: Urbanization activities and inadequate stormwater management (such as stream channel modification for flood control or gravel extraction) that could cause an increase in bank erosion; significant changes in the existing flow regime within the streams due to water diversion or withdrawal; significant alteration of water quality; significant alteration in the quantity of groundwater, prevention of water from percolating into the aquifer recharge zone, and alteration of spring discharge sites; significant changes in stream bed material composition and quality due to construction projects and maintenance activities; off-road vehicle use; sewer, gas, and water easements; bridge construction; culvert and pipe installation; and other watershed and floodplain disturbances that release sediments or nutrients into the water. Other activities that may affect physical and biological features in the critical habitat units include those listed in the Effects of Critical Habitat Designation section below. Management activities that could ameliorate these threats include, but are not limited to: Use of BMPs designed to reduce sedimentation, erosion, and bank side destruction; moderation of surface and ground water withdrawals to maintain natural flow regimes; increase of stormwater management and reduction of stormwater flows into the systems; preservation of headwater springs, spring runs, and ephemeral rivulets; regulation of off-road vehicle use; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the areas we are designating as critical habitat for the rush darter contain the physical or biological features for the species, and that these features may require special management considerations or protection. Special management consideration or protection may be required to eliminate, or to reduce to negligible levels, the threats affecting the physical or biological features of each unit.

Life History

Feeding Narrative

Adult: Adults and immatures are invertivores. Food items are likely similar to the goldstripe darter, which eats midges, mayflies, blackflies, beetles, and microcrustaceans (NatureServe, 2015).

Reproduction Narrative

Adult: Tuberculate males with breeding colors, and females with large ripening oocytes, have been taken in March and April (Bart and Taylor 1999). The life history of the rush darter is poorly known, but its life history characteristics are likely similar to the goldstripe darter. Spawning of the goldstripe darter occurs from mid-March through June in Alabama (Mettee et al. 1996) and from mid-April through May in Tennessee and Mississippi (Etnier and Starnes 1993). [From USFWS 2002] (NatureServe, 2015). The lifespan of the goldstripe darter is estimated to be 2 to 3 years (USFWS, 2011).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate to broad (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015; see dispersal/migration narrative)

Habitat Narrative

Adult: Rush darters have been collected from various habitats (Bart and Taylor 1999, Johnston and Kleiner 2001, Stiles and Blanchard 2001, Boschung and Mayden 2004): root masses of emergent vegetation along the margins of spring-fed streams in very shallow, clear, cool and flowing water; small clumps and dense stands of bur reed (Sparganium sp.) and coontail (Ceratophyllum sp.) in streams with substrates of silt, sand, sand and silt, muck and sand or some gravel with sand, and bedrock. They appear to prefer relatively low gradient small streams, and some of the streams where they occur are not influenced by springs. Water depth at collection sites ranges from 3.0 cm to 0.5 m with moderate water velocity in riffles and no flow or low flow in pools. No rush darters have been found in higher gradient streams with bedrock substrates and sparse vegetation, and they also have not been found in dense growths of watercress (Nasturtium officinale) along the sides and mid-channel of spring runs. Primary source: USFWS (2002). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Data on dispersal and other movements generally are not available (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 10-30% (NatureServe, 2015)

Species Trends:

Declining (NatureServe, 2015)

Number of Populations:

6 - 20 (NatureServe, 2015)

Population Size:

250 - 1000 individuals (NatureServe, 2015)

Population Narrative:

Currently, about 3 km of stream, or about 22 percent of the rush darters known range, is not occupied (USFWS 2011). This species has experience a long-term decline of 10-30%. Where it occurs, the rush darter is apparently an uncommon species that is usually collected in low numbers (Bart and Taylor 1999). Since 1969, approximately 100 rush darters have been collected or captured and released within the species' range (compiled from Bart and Taylor 1999, Johnston and Kleiner 2001, Stiles and Blanchard 2001). Within the Clear Creek drainage in Winston County, the most individuals captured in one collection was six (6) from Mill Creek in August 2001 (Johnston and Kleiner 2001). Bart and Taylor (1999) reported collecting up to 11 individuals during a survey of Wildcat Branch between 1990 and 1993. However, only one individual was collected by Johnston and Kleiner (2001) in August 2001 at a road crossing of Wildcat Branch, and Stiles and Blanchard (2001) did not collect rush darters in that locality later that same month after several attempts. In Jefferson County, collections have also been sporadic, with four individuals recorded at the Penny Springs site (Stiles and Blanchard 2001), seven individuals at the unnamed spring run that is the type locality (Stiles and Blanchard 2001, Drennen pers. obs. 2001), and only one individual at a bridge crossing over the same unnamed spring run (type locality). However, no rush darters were collected at the bridge crossing over the spring run 1 week later (Stiles and Blanchard 2001; Drennen, pers. obs., 2001). [from USFWS 2002]. Drennen (2003) reported that researchers from Auburn University estimated the species' total population at not more than 500 individuals. This species is represented by about 8 occupied areas in three watersheds (USFWS 2011). The range extent is 400 - 2,000 square miles. Distribution and/or abundance probably are declining (USFWS 2011) (NatureServe, 2015).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Threats to rush darter include stormwater runoff and siltation, caused by an increase in urbanization and impervious surfaces in the watershed. Other threats include spring head alteration, roadside maintenance, and logging. These threats are ongoing and thus considered imminent. The magnitude of the threats is high due to the small population sizes and high levels of alterations and destruction of the springs and streams. Sediment is the most abundant pollutant in the Mobile River Basin (Alabama Department of Environmental Management 1996, pp. 14–15) and a major threat to the rush darter. 008, p. 5; Fluker et al. 2007, p. 10). Springs throughout the rush darter’s range, especially in Pinson Valley, flush and dilute sediments and excessive nutrients from streams by providing a constant flow of cool, clean water. However, the ongoing destruction of spring heads and wetlands throughout the species’ range has significantly reduced the species’ movement and colonization. Channelization and groundwater withdrawals from spring heads might do more to impact water quality in these systems than overall spring drainage disturbances such as beaver dam construction, and road maintenance (Drennen per. obs. 2005). Alteration of spring head habitats has reduced water quality and increased sediment loads into spring-fed tributary streams throughout the range of the rush darter (USFWS, 2011).

Stressor: Restricted range and population size (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: The rush darter has a limited geographic range and small population size. The existing populations are extremely localized, and geographically isolated from one another, leaving them vulnerable to localized extinctions from intentional or accidental toxic chemical spills, habitat modification, progressive degradation from runoff (non-point source pollutants), natural catastrophic changes to their habitat (e.g., flood scour, drought), other stochastic disturbances, and to decreased fitness from reduced genetic diversity. The level of isolation seen in this species makes natural repopulation following localized extirpations virtually impossible without human intervention (USFWS, 2011).

Stressor: Climate change (USFWS, 2011)
Exposure:
Response:

Consequence:
Narrative: Climate change is expected to result in increased frequency and duration of droughts and the strength of storms (e.g., Cook et al. 2004). Fluker et al. (2007, p. 10) reported that drought conditions, coupled with rapid urbanization in watersheds that contain rush darters, render the populations vulnerable, especially during the breeding season when they concentrate in wetland pools and shallow pools of headwater streams (USFWS, 2011).

Stressor: Watercress darter (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: The Federally endangered watercress darter (Etheostoma nuchale) was translocated outside of its native range by the Service into Tapawingo Springs in 1988 in order to assist in the species' recovery by expanding its range (Moss 1995, p. 5). The watercress darter is now reproducing and is competing with the rush darter in Tapawingo Springs (USFWS 1993, p. 1; Drennen pers. obs. 2004; George et al. 2009, p. 532). In 2001, a population of watercress darters was found in the Penny Springs site (Stiles and Blanchard 2001, p. 3). The introduced watercress darter appears to be out-competing the rush darter at this site (Fluker et al. 2008, p. 1; George et al. 2009, p. 532) (USFWS, 2011).

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Delisting Criteria:
Not available - this species does not have a recovery plan.

Recovery Actions:
- Not available - this species does not have a recovery plan.

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS The following recovery actions should be made a priority over the next 5 years: 1. Complete a recovery plan. 2. Continue to monitor habitat quality throughout the range of the species. Identify and develop partnerships to restore and protect habitats. 3. Conduct quantitative surveys in each occupied spring and stream segment to determine and monitor population size. 4. Continue research efforts on population genetics; use results of the study to inform recovery efforts. 5. Conduct a life history study for the species. 6. Continue to search for unknown populations. 7. Increase public awareness of the species through outreach efforts, including webbased educational materials, fact sheets, regional publications, and media sources such as public television. (USFWS, 2019)

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SPECIES ACCOUNT: *Etheostoma rubrum* (Bayou darter)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/28/1975; Southeast Region (R4) (USFWS, 2015)

Physical Description

A 2-inch fish (darter) (NatureServe, 2015). Etheostoma rubrum is sexually dimorphic with both sexes having a prominent double basicaudal spot and black subocular bar. The male reaches a larger size and has a narrow, terminal clear area and a subterminal black band of equal width on the caudal fin. The remainder of the caudal fin has a narrow, yellow band with fin rays that are reddish with some yellow. The female has a series of four or five russet or red wavy lines on the caudal fin (USFWS, 1990).

Taxonomy

Subgenus NOTHONOTUS. Closely related to E. MOOREI of Devil's Fork and Little Red River of the White River system. (NatureServe, 2015)

Historical Range

Etheostoma rubrum has been collected only from Bayou Pierre and its tributaries: White Oak Creek, Foster Creek, and Turkey Creek (Figure 1) (Teels et al. 1977; Suttkus and Clemmer 1977; Ross et al. 1989a) (USFWS, 1990).

Current Range

Range is restricted to Bayou Pierre and its tributaries, including White Oak Creek, Foster Creek, and Turkey Creek (see maps in Ross et al. 1992, 2001; Page and Burr 2011). Bayou Pierre is a tributary of the Mississippi River in western Mississippi. Densities are highest in the upper parts of the Bayou Pierre system, but the species also persists as apparently self-sustaining populations in the middle and lower reaches of Bayou Pierre, at least down to its confluence with Little Bayou Pierre (Slack et al. 2004). Bayou Pierre watershed encompasses about 2,500 square kilometers, 700 square kilometers of which is occupied by E. rubrum (Slack et al. 2010). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Feeds primarily on midges, blackflies, water mites, caddisflies, and mayflies; greatest feeding intensity in April before spawning (USFWS 1990). Young may feed almost exclusively on mayfly larvae. Adults and immatures are invertivores (NatureServe, 2015).

Reproduction Narrative

Adult: Reproductively active females occur mid-April (or early May) to mid-August at water temperature of 20-30 C; peak spawning April to late May or early June during rising water temperatures; juveniles first collected in late July in one year, late August in the next year, but also reported as early as June. Most first spawn after their first year and do not live beyond 3 years (a few males do). Individual females probably spawn at least twice per season. See Burris and Bagley (1983), USFWS (1990), Knight and Ross (1992). Bayou darters apparently are egg buriers that probably use fine gravel or coarse sand (Ross and Wilkins 1993) (NatureServe, 2015). Females may produce 80 eggs over the spawning season, which may occur twice within the period. Eggs are buried and unattended (Ross 2001) (USFWS, 2012). Clutch sizes range from 20—75 ova (USFWS, 1990).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: This darter inhabits fast rocky riffles of shallow, meandering creeks an d small to medium rivers (Page and Burr 2011). It prefers stable, moderately swift riffles and runs over large gravel and rock, and it seldom occurs over shifting substrates. Adults most commonly are collected near heads of gravel riffles in water less than 15-30 centimeters deep. Upstream distribution apparently is limited by low water flow in summer and fall (USFWS 1990). Ross et al. (1990, 1992) characterized the habitat as mid-reach (typically third to fourth order) stream sections, with swift (mean 79 cm/sec), shallow water and firm coarse substrates (mean particle size 16-32 mm); in winter, bayou darters were associated with logs, cobble, and boulders, which may comprise important refugia during periods of high stream flow. Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (inferred from USFWS, 2012)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Some larvae drift from spawning sites (Slack et al. 2004). Data on dispersal and other movements generally are not available (NatureServe, 2015). Downstream drift for approximately 300 meters of protolarvae and mesolarvae life stages may occur in bayou darters (USFWS, 2012).

Population Information and Trends

Population Trends:
Relatively Stable (<=10% change) (NatureServe, 2015)

Species Trends:
Stable (USFWS, 2012)

Number of Populations:
1 - 5 (NatureServe, 2015)

Population Size:
10,000 - 100,000 individuals (NatureServe, 2015)

Population Narrative:
Density was stable in the 1980s and 1990s, but distribution shifted upstream due to ongoing geomorphic changes (headcutting) (Ross et al. 2001). The long-term trend is relatively Stable (<=10% change). Total adult population size is unknown but presumably exceeds 10,000. Ross et al. (2001) collected 1,108 bayou darters during 1986-1994; density in riffles averaged around one bayou darter per square meter. This species is represented by a small number of occurrences in four streams (here regarded as four locations) (see map in Slack et al. 2010). The range extent is 100 - 400 square miles (NatureServe, 2015). The species status is stable; periodic surveys indicate consistent number caught per unit effort but no indication that populations are robust. The bayou darter exhibits low genetic diversity which may be best explained by its small range and by recent genetic bottleneck (Slack et al. 2010) (USFWS, 2012).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The principle threats are habitat alteration, water quality and quantity degradation. The Bayou Pierre River watershed is undergoing major geomorphic changes, especially in the headwaters, affecting the distribution of the bayou darters. Knickpoints are disturbances within the channel that cause an unstable situation where the bottom and sides of the channel may gradually produce a deepening and widening, along with an abundance of suspended sediments, impacting water quality. The process of headcutting may occur simultaneously with supplementary headcutting, which is caused by a variety of knickpoints such as gravel mining, ditching etc., and may venture up tributaries. Anthropogenic changes initiated with historical sand and gravel extraction and accelerated with agricultural practices that extend along the bankside within the watershed produce geomorphic changes that continue to add tremendous amounts of sediment to the river system. Slack et al. (2004) emphasized the importance of disjunctive riffle habitat and the downstream transport of larvae in relation to gene flow between riffle catchments and possibly weakening the population overall. How the changes in the Bayou Pierre River's geomorphology which includes less pools and riffles will affect the species different life stages is unknown (USFWS, 2012).

Stressor: Restricted range (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The current range of the bayou darter is restricted to localized sites within the Bayou Pierre River drainage. Subsequently, genetic diversity has likely declined due to fragmentation and separation of bayou darter populations. The long-term viability of a species is based on conservation of numerous local populations throughout its geographic range (Harris 1984). These features are essential for the species to recover and adapt to environmental change (Noss et al. 1994, Harris 1984). Interbreeding populations of bayou darters are becoming increasingly disjunctive. This disjunctive distribution makes bayou darter populations vulnerable to extirpation from catastrophic events, such as toxic spills, large in-stream-gravel mining projects, or changes in flow regime caused by extensive pumping for agriculture and drought (USFWS, 2012).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. Evidence of a stable or increasing population over at least a 10—year period in Bayou Pierre and Foster Creek (USFWS, 1990).

2. Evidence of the continued existence of the bayou darter in White Oak and Turkey Creeks (USFWS, 1990).

3. Data on the fluvial geomorphic processes operating in the Bayou Pierre system which indicates a trend of no net loss of, or improving, habitat for the species (USFWS, 1990).

4. An established continuing plan of periodic monitoring of population trends and habitat stability (USFWS, 1990).

5. Protection of bayou darter habitat through full implementation of task 4 of this recovery plan (USFWS, 1990).

Recovery Actions:
- Monitor occupied habitat and population trends (USFWS, 1990).
- Obtain additional biological information essential to management of the species (USFWS, 1990).
- Identify factors causing degradation of the E. rubrum habitat (USFWS, 1990).
- Protect darters and their habitat (USFWS, 1990).
- Initiate consistent annual long-term monitoring of the species along with its habitat in the Bayou Pierre River and tributaries (USFWS, 2012).
- Initiate geomorphic analysis within the upper/headwater reach of the Bayou Pierre River. Determine significant problem areas within the upper reach and formalize plans to abate

and reduce the impact (USFWS, 2012).

- Continue work to obtain protection for sites on privately owned lands through the Bayou Pierre River Enhancement Group. Incorporate all stakeholders in determining long-term and short term strategy for management of the watershed and lessening the impact of headcutting and prevention of future nick points (USFWS, 2012).
- Work with state, county and town governments in establishing best management and conservation practices to improve water quality and water quantity issues, through number 3 above (USFWS, 2012).
- Revise and or update recovery plan (1990) to include new stakeholders and priorities based on land use and geomorphic changes (USFWS, 2012).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Initiate consistent annual long-term monitoring of the species and its habitats in the Bayou Pierre River and tributaries. 2. Conduct geomorphic studies within the upper/headwater reach of the Bayou Pierre River. 3. Identify actions to stabilize accelerated geomorphic changes throughout the system. 4. Revise and or update the recovery plan (1990) to identify new stakeholders and priorities based on geomorphic changes and distributional shifts. (USFWS, 2020)

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SPECIES ACCOUNT: *Etheostoma scotti* (Cherokee darter)

Species Taxonomic and Listing Information

Listing Status: Threatened; 12/20/1994; Southeast Region (R4) (USFWS, 2015)

Physical Description

A small fish (darter). A small cylindrical percid with a relatively blunt snout and a subterminal mouth; body white to pale yellow; adults have on each side usually eight dark blotches, which increase in size when breeding; dorsum has usually eight dark saddles (USFWS 1993). See Bauer et al. (1995). The length is 5 cm. (NatureServe, 2015)

Taxonomy

Recent research shows that three genetically distinct groups of Cherokee darters exist in the Etowah River basin, corresponding with the upper, middle and lower portions of the watershed. (NatureServe, 2015)

Historical Range

The Cherokee darter is endemic to the Etowah River system in north Georgia. Historically, it was thought to have occurred in most tributaries of the watershed. (USFWS, 2000)

Current Range

This darter is endemic to the Etowah River system in northern Georgia (Bauer et al. 1995), from Raccoon Creek to Camp Creek and unnamed tributaries of the Etowah River near Dahlonega, Georgia (Freeman and Wenger 2006). It is primarily restricted to streams draining the Piedmont physiographic province and to a lesser extent the Blue Ridge physiographic province. The largest populations occur in the northern tributaries upstream of Allatoona Reservoir (USFWS 1993). See Bauer et al. (1995) for further details. (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Adults and immatures are invertivores (NatureServe, 2015). Cherokee darters presumably prey upon midge and black fly larvae and other small aquatic invertebrates (USFWS, 2014).

Reproduction Narrative

Adult: Spawning season extends from mid-March to mid-June (Storey et al. 2006); peak in April (Barton and Powers 2010). Cherokee darters deposit single eggs in small depressions or recesses on the surface of large gravel, small cobble and occasionally woody debris within runs, moderate to slow riffles and the tails of pools (Freeman and Wenger 2006, Storey et al. 2006). Sexual maturity occurs at age 1; maximum age is 2 years (Barton and Powers 2010) (NatureServe, 2015). The male pursues the female and attempts to fertilize each egg as it is deposited (USFWS, 2014).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: Habitat includes pools and adjacent riffles of creeks and small rivers (Page and Burr 2011), about 1-15 meters wide, with moderate gradient and predominantly rocky bottoms; usually in shallow water in sections of reduced current, typically in runs above and below riffles and at the ecotones of riffles and backwaters; associated with large gravel, cobble, and small boulder substrates; uncommonly or rarely over bedrock, fine gravel, or sand; most abundant in sections with relatively clear water and substrates mainly clear of silt (intolerant of moderate or heavy silt deposition); intolerant of impoundment (USFWS 1993, Bauer et al. 1995). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Not available

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Not available

Dispersal/Migration Narrative

Adult: This species is non-migratory. Data on dispersal and other movements generally are not available (NatureServe, 2015).

Population Information and Trends

Population Trends:

Unknown - probably declining (NatureServe, 2015)

Species Trends:

Decreasing (USFWS, 2014)

Number of Populations:

21 - 80 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

Total adult population size is unknown; individual subpopulations are generally small (USFWS 2000). This darter is recently known from well over 100 collection sites in several dozen small to moderately large tributary streams (see map in Etowah Aquatic Habitat Conservation Plan (http://www.etowahhcp.org/background/species/scotti.htm). Trend over the past 10 years or three generations is uncertain, but distribution and abundance probably are slowly declining. The range extent is 400 - 2,000 square miles (NatureServe, 2015). The species status is decreasing; construction/filling of the Hollis-Latham and Hickory Log Creek Reservoirs impacted two large populations of this fish (USFWS, 2014).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The Cherokee darter listing document identifies the primary causes of habitat destruction, modification, or curtailment as: impoundments that result in habitat loss, population extirpation, fragmentation, and changes in the thermal regime below dams that favors predatory fishes; siltation associated with timber clearcutting, clearing of riparian vegetation, and construction, mining, and agricultural practices that allow dirt to enter streams; increased development and land clearing that increases siltation from erosion, accelerates runoff, allows transport of pollutants into the Etowah River system, and requires additional road and landfill infrastructure; bridges, railroad crossings, and other stream crossings that are potential sites for spills of toxic material due to vehicle accidents, deliberate dumping, and other means; pollution from other point and nonpoint sources such as municipal and industrial waste discharges, agricultural runoff, poultry processing plants, and silvicultural activities. None of these threats have been eliminated in the 20 years since the species was listed (USFWS, 2014).

Stressor: Climate change (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: In the Southeast through the 21st century, climate models project that average annual temperatures will increase, cold days will become less frequent, the freeze-free season will lengthen by up to a month, temperatures exceeding 95 degrees will increase, heat waves will become longer, sea levels will rise an average of 3 feet, the number of category 3 to category 5 hurricanes will increase, and air quality will decline (Ingram et al. 2013). Aquatic systems will be impacted by increasing water temperatures, decreasing dissolved oxygen levels, altered

streamflow patterns, increased demand for water storage and conveyance structures, and increasing toxicity of pollutants (Ficke 2007, Rahel and Olden 2007). Reduced spring/summer rainfall, coupled with increased evapotransporation and water demand (because of population growth), could lead to local extirpations if streams dry out more frequently (Ingram et al. 2013) (USFWS, 2014).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. Known populations of the species are shown to be stable or increasing for at least five years (USFWS, 2014).

2. Plans are developed to protect and monitor water and habitat quality in all occupied streams (USFWS, 2014).

Recovery Actions:
- Protect habitat integrity and quality (USFWS, 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS, 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS, 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS, 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS, 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS, 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS, 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS, 2000).
- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS, 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS, 2000).
- Work with local governments in the Etowah River basin to develop a new HCP(s) or other basin wide management plan to protect aquatic resources (USFWS, 2014).
- Develop a conservation banking program in the Etowah River basin to compensate for loss of aquatic habitats that support Etowah darters (USFWS, 2014).
- Work to establish a Conasauga River conservation area to protect high priority amber darter reaches (USFWS, 2014).
- Fund annual long-term monitoring of these species in the Etowah and Conasauga basins (USFWS, 2014).
- Develop a baseline database on stream geomorphic characteristics in high quality Cherokee darter streams. Use these data to revise stream restoration methods commonly used in the basin to ensure development of habitat for benthic shoal-dwelling fishes is a primary

restoration project component (where applicable) (USFWS, 2014).
- Complete the chemical profile of the Conasauga. If agricultural contaminants appear to be a major stressor on amber darters and other protected and rare species in the Conasauga, work with NRCS to reduce input into the River (USFWS, 2014).
- Complete the study to evaluate intersex fish incidence in the Conasauga. Concurrently, evaluate the effect of environmental estrogens on public health and communicate these results to GEPD and local governments (USFWS, 2014).
- Develop and implement programs and materials to educate government officials and the public on the need and benefits of ecosystem management and to involve them in watershed stewardship for these and other aquatic species (USFWS, 2014).
- Work with GEPD and EPA to incorporate listed species' review into NPDES point-source and construction permit review (USFWS, 2014).
- Continue to hold periodic Conasauga and/or Coosa Summits to bring together researchers, land managers, environmental groups, local government officials, and others to discuss recent Conasauga/Coosa research results, new threats, and needed management actions. Continue to meet in smaller committees, as needed, to discuss management actions to address stressors (USFWS, 2014).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The following are future actions for Cherokee darter recovery: • Work with local governments in the Etowah River basin to continue improving local ordinances that minimize impact of development on water quality and suitable habitat. • Continue to establish mitigation options that benefit Cherokee darter including conservation banking. • Fund annual long-term monitoring of Cherokee darter status surveys to determine if Criteria 1 is being met. • Develop a baseline database on stream geomorphic characteristics in high quality Cherokee darter streams. Use these data to revise stream restoration methods commonly used in the basin to ensure development of habitat for benthic shoal-dwelling fishes is a primary restoration project component (where applicable). • Develop and implement programs and materials to educate government officials and the public on the need and benefits of ecosystem management and to involve them in watershed stewardship for Cherokee darter and other aquatic species • Continue to work with GA DNR, TNC and other partners to protect high quality lands throughout the Etowah Watershed, but especially in the Raccoon Creek, Smithwick Creek and Shoal Creek (Dawson County) watersheds. • Work with GEPD and EPA to incorporate listed species' review into NPDES point-source and construction permit review • Continue to hold periodic Coosa Summits to bring together researchers, land managers, environmental groups, local government officials, and others to discuss recent Coosa research results, new threats, and needed management actions. Continue to meet in smaller committees, as needed, to discuss management actions to address stressors. (USFWS, 2021)

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SPECIES ACCOUNT: *Etheostoma sellare* (Maryland darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/11/1967; Northeast Region (Region 5) (USFWS, 2015)

Physical Description

Adult Maryland darters may be separated from other darters by using the following combination of characters: gill membranes slightly conjoined, presence of approximately four dark saddles across the back, complete lateral line and presence of a small dark spot behind the lower rear margin of the eye. (USFWS, 1985)

Taxonomy

Radcliffe and Welsh (1913) placed the new species in the genus Hadropterus. Noting the lack of caducous scales, Habbs and Black (1940) re-assigned Etheostoma sellare to Poeclichthys. Bailey and Gosline (1955) envisioned the subgenus Etheostoma as including E. sellare and 14 other species. Collete (1965), placed E. sellare with the non-tuberculate E. inscriptum species group. Richards (1966) used differences in dentition, tuberculation, body shape, color pattern and habits to distinguish three species groups within the subgenus Etheostoma and two specialized relatives, E. blennius and E. sellare. Because of its specialized head shape and naked body, Tsai (1966) concluded that E. sellare diverged very early from other members in the evolution of the subgenus Etheostoma. (USFWS, 1985)

Historical Range

Known only from tributaries of the lower Susquehanna River, Harford County, Maryland (Page and Burr 2011). Most recently, this species was restricted to a single riffle in Deer Creek (the only known extant population in the 1980s); occasional strays have occurred in Gasheys Run downstream (where breeding habitat apparently is lacking). No recent records from type locality (Swan Creek, near Havre de Grace, Maryland). (NatureServe, 2015)

Current Range

All collections or observations of the Maryland darter have occurred in three Harford County, Maryland streams: Swan Creek, Gashey's Run, and Deer Creek. (USFWS, 2007)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/29/1984.

Legal Description

On August 29, 1984, the Service designated critical habitat for the Maryland darter (Etheostoma sellare). The action, based on recommendations of Service biologists, the State of Maryland, and a recovery team, specifies 2.8 miles of 2 streams that are considered critical to survival of this fish.

Critical Habitat Designation

The critical habitat for Etheostoma sellare includes two steams totaling 2.8 miles in Harford County, Maryland.

1. Deer Creek main channel from the junction with elbow Branch thence downstream to the junction with the susquehanna River.

2. Gasheys Run (also known as Gasheys Creek) main channels of east and west forks from their overcrossing by old Penn Central Railroad (presently titled to National Railroad Passenger Corporation, Amtrak) south to their confluence, thence south to the confluence with Swan Creek.

Primary Constituent Elements/Physical or Biological Features

The following elements are known or believed to be constituent elements in the designated critical habitat of the Maryland darter:

I. Continuity und sufficiency of stream flow. Like most fishes, this one could not be expected to survive removal of all water from its habitat for more than a few minutes.

2. Permanence of riffle habitat. Like many other darters, this one shows evidence of permanent residence in the shallower, swifter segments of streams. Both reproduction and ultimately survival can reasonably be predicted to be adversely affected if the population is forced by low water into stagnant or even still pools for prolonged periods. This contraint probably holds for most organisms that'are the darter's natural food.

3. Pollution sensitivity. Coupled with most darters' preference for swift water is a high oxygen requirement, making darters among the first fishes to show respiratory stress and failure with any reduction of oxygen availability. Selective mortality of darters in habitats subjected to various other kinds of pollution is also documented.

4. Presence and quality of cover. Darters inhabiting riffles are known to use crevices among stones, smaller pebbles, vegetation or trapped wood flotsam both for cover from their predators and for spawning and egg protection. They have been noted to disappear from riffles when silt deposition eliminated such crevices. Darter eggs have been shown to be particularly vulnerable to smothering by silt, so that even less siltation can normally be tolerated during the spawning season.

Special Management Considerations or Protections

Water drawdown by Aberdeen Proving Ground could, during times of extreme drought, conceivably adversely affect the designated area by forcing darters into pool areas for extended periods. a regular basis. Construction of dams or other structures traversing Deek Creek that would impound the stream segments designated as critical habitat would almost certainly destroy the Maryland darter population. Impoundment upstream could adversely change temperature relationships within the stream. Activities involving the introduction of chemicals, organic waste matter of silt into the streams comprising the critical habitat may adversely affect such areas.

Life History

Feeding Narrative

Adult: Stomach content analysis of five specimens take in November, 1965 revealed a large number of snails, parts of 11 caddisfly larvae, two stonefly nymphs, and one mayfly. Diet includes snails and immature aquatic insects (Ono et al. 1983), and some plant matter (Matthews and Moseley 1990). (NatureServe, 2015; USFWS, 1985)

Reproduction Narrative

Adult: Spawning period probably is late April or early May (Ono et al. 1983). Maximum life span probably is less than 3 years (Page 1983). (NatureServe, 2015)

Geographic or Habitat Restraints or Barriers

Adult: Dam lacking a suitable fishway; high waterfall; upland habitat (NatureServe, 2015)

Habitat Narrative

Adult: Habitat includes fast rocky riffles of creeks (Page and Burr 2011). As of the 1980s, this darter inhabited the first major riffle above tidewater in Deer Creek; it also used (particularly young and juveniles) adjacent pools. Riffle has bottom ranging from rubble to gravel and has an abundance of rooted aquatic plants (Kuehne and Barbour 1983, Page 1983). Spawning occurs probably in gravel riffles. Habitat barriers for Maryland Darters include dams, high waterfalls, and upland habitat. (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: High (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Data on dispersal and other movements generally are not available. Though larvae of some species may drift with the current. (NatureServe, 2015)

Population Information and Trends

Population Trends:

Likely extinct (USFWS, 2021)

Species Trends:

Likely extinct (USFWS, 2021)

Number of Populations:

0 (USFWS, 2021)

Population Size:

0 (USFWS, 2021)

Population Narrative:

This species probably is extinct. It was most recently confirmed from the last known location (Deer Creek) in 1986; one possibly was found there in 1988 (Lynn Davidson, pers. comm., 1997; see also USFWS, Federal Register, 15 February 1996). Historically the species was represented by small local population sizes of less than 100 individuals, less than 30 in two of the three sites (R. Raesly, pers. comm., 1995). Surveys in the early 1980s found only 1-10 individuals at any locality (Matthews and Moseley 1990). Would not be unexpected for the species to "reappear." (NatureServe, 2015). The Maryland darter has not been observed or collected since 1988 in Deer Creek, or any other sites, despite intensive survey efforts. Since the last 5-Year Review in 2007, surveys were conducted from 2008 through 2010, 2012, and 2020 through 2021. Surveys were conducted over different seasons and with different gear types at all of the historical locations and also in Octoraro Creek and Mill Creek and along the mainstem of the Susquehanna River. The Service used the Reed (1996, entire) method to look at the statistical probability that the Maryland darter is still present by looking at survey effort for the species (presence/absence) and using measures of detectability found in the literature for other darter species. Using the average detection probability from the literature (0.43), we found that there was only a 1-percent chance that the Maryland darter is still present and it was not detected with the survey effort that has occurred (appendix B). Therefore, we conclude that it is highly likely that the species is extinct (USFWS, 2021)

Threats and Stressors

Stressor: Small population size (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: The very low numbers of Maryland darter that have been observed since the species was listed, particularly the absence of any collections or observations of the species since 1988, are a clear indication of the species' vulnerability to small population effects such as inbreeding depression. (USFWS, 2007)

Stressor: Unrestricted water and land uses (USFWS, 1985)
Exposure:
Response:
Consequence:
Narrative: Several consequences of poor land uses observed in Deer Creek include prolonged periods of high turbidity; impoundments; runoff containing excessive nutrients, organic wastes, ammonia, pesticides, herbicides, and other toxic substances; sewage plant malfunction or flooding resulting in excessive chlorine and untreated sewage being introduced into the stream; accidental discharge of liquid manure; long term effects of chloroamines; reduction of stream flow by withdrawals for consumptive uses; construction projects which have potential for spills and lethal runoff; and leachate from sanitary landfills. (USFWS, 1985)

Recovery

Reclassification Criteria:
1. Establish and utilize a Maryland Darter/Deer Creek Management Group. (USFWS, 1985)

2. Determine species' requirements and range including life history and habitat requirements. (USFWS, 1985)

3. Protect and maintain the existing Maryland darter population. (USFWS, 1985)

4. Protect, maintain, and enhance existing Maryland darter habitat. (USFWS, 1985)

5. Develop public and scientific awareness of the need to accomplish the primary objective of the plan (USFWS, 1985)

Delisting Criteria:
Downlisting criteria as described in the 1985 Maryland darter Recovery Plan requires "six discrete populations" of the species prior to consideration. No delisting due to recovery criteria were developed at that time because this was not considered possible given known conditions. This remains the case (USFWS,2019).

Recovery Actions:
- Recovery actions are not available.
- To provide reliable data upon which to base a decision concerning the Maryland darter's continued existence, it is recommended that at least 2 additional years of intensive surveying for the Maryland darter, by electrofishing/seining, be completed in the lower reaches of six Susquehanna River tributaries (Deer Creek, Gashey's Run, Swan Creek, Broad Creek, Octaroro Creek, and Conowingo Creek), with emphasis on the three streams having historic records for the species (Deer Creek, Gashey's Run, and Swan Creek). (USFWS, 2007)

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SPECIES ACCOUNT: *Etheostoma sp.* (Bluemask (=jewel) Darter)

Species Taxonomic and Listing Information

Commonly-used Acronym: Etheostoma akatulo

Listing Status: Endangered; 12/27/1993; Southeast Region (R4) (USFWS, 2015)

Physical Description

A small fish (darter) that reaches a maximum standard length of 48 mm. A small (1.75-inch) fish; breeding males are nearly all bright blue, females and nonbreeding males are not so brightly colored; six dark saddle-like markings across the back; 7-8 lateral blotches (USFWS 1992). The length is 5 cm. (NatureServe, 2015)

Taxonomy

Formerly included as a subspecies of the speckled darter (Etheostoma stigmaeum). (NatureServe, 2015)

Historical Range

Historically, the bluemask darter was also collected in the Calfkiller River (White County), but is now believed to be extirpated from that system. (USFWS, 2013)

Current Range

Range includes the upper Caney Fork River System of the middle Cumberland River drainage, Tennessee (Page and Burr 2011); species is presently known from four tributaries of Great Falls Reservoir on the eastern Highland Rim (Layman and Mayden 2009). Collection sites include the Upper Caney Fork River, Collins River, Rocky River, Calfkiller River (apparently now extirpated), and Cane Creek, in Grundy, Warren, Van Buren, and White counties (Layman 1991). Recent sampling in the Barrens Fork River, Falling Water River, Charles Creek, Laurel Creek, Hickory Creek, Town Creek, and Mountain Creek yielded no specimens (Layman 1991). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Adults and immatures are invertivores (NatureServe, 2015). The bluemask darter appears to generally feed on the larvae of aquatic insects and other small aquatic invertebrates (Service 1997; Etnier and Starnes 1993). J. W. Simmons, pers. comm. 2012, indicated that from field observations he believes they feed on chironomid larvae present in sand substrate (USFWS, 2013).

Reproduction Narrative

Adult: In the Collins River, some age 1 individuals were sexually mature, but the majority of the reproductive population comprised older fish (Simmons and Layzer 2004). Spawning males were collected from the Collins River over sand and gravel in moderately flowing runs. In the Collins River, spawning occurred in runs at mean water depths of 21.4 cm, bottom velocities of 18.9 cm/sec, and water column velocities of 28.9 cm/sec; substrate was dominated by gravel in areas occupied by lone males and spawning pairs, whereas most lone females were found over a sand-dominant substrate; spawning microhabitats differed from habitats used during the summer (Simmons and Layzer 2004) (NatureServe, 2015). Eggs are deposited and buried in pockets of sand (USFWS, 2013).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: Moderate (inferred from NatureServe, 2015; see dispersal/migration narrative)

Habitat Narrative

Adult: Habitat includes rocky pools, runs, and riffles of clear creeks and small rivers (Page and Burr 2011); this species typically occurs over sand and gravel substrates downstream of riffles, in moderate runs, or along margins of pools (Layman and Mayden 2009). Habitat includes areas of slow to moderate current with sand and fine gravel substrates, at depths of 10-50 cm, typically just downstream of riffles or along the margins of pools and runs (Layman 1991, USFWS 1995). Lower free-flowing reaches of streams on the Highland Rim, which are characterized by moderate gradient, low to moderate productivity, and substrates of limestone or chert bedrock, coarse chert gravel, and sand (see USFWS 1995). Main stream width at three localities was 14 to 28 m; mean depth was 24 to 28 cm (USFWS 1995). The upper reaches of all four occupied streams flow underground in summer with little or no surface flow; this limits perennial habitat to the lower stream reaches (USFWS 1995). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). Since completion of the previous 5-year review, the known distribution of the bluemask darter has been extended by 2.2 river km (1.4 mi) in Cane Creek (TVA 2019) and 8.5 river km (5.3 mi) in the Collins River (Mattingly et al. 2018). However, the bluemask darter continues to be affected by operation of Great Falls Dam and presence of the reservoir. Recovery will continue to be difficult due to recurring habitat alterations from the effects of impoundment and the presence of the reservoir. Bluemask darters are likely unable to migrate and establish additional populations in tributary streams, such as the Calfkiller River. Sedimentation, other water quality impacts, and the potential for toxic chemical spills also remain threats to the bluemask darter. (USFWS, 2020)

Dispersal/Migration

Motility/Mobility

Adult: Moderate (inferred from USFWS, 2013)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Moderate (inferred from USFWS, 2013)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015). Several individuals sampled in the lower Caney Fork have shown large genetic contributions from the Rocky River and the reverse, individuals found in the Rocky River population have shown genetic contributions from the lower Caney Fork population, indicating that migrants are exchanged between populations inhabiting separate tributaries (Robinson et al. 2012) (USFWS, 2013)

Population Information and Trends

Population Trends:

Unknown (USFWS, 2013)

Species Trends:

Stable (USFWS, 2013)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

Total adult population size is unknown. This species is regarded as rare (Page and Burr 2011). Historically known from five rivers; now known from four rivers (USFWS 1995, 1997; Layman and Mayden 2009). Probably was formerly more widely distributed than available records indicate. The range extent is 100 - 400 square miles (NatureServe, 2015). Based on recent survey data collected by TVA, the overall status of the bluemask darter appears to have remained stable. Long term monitoring data are not yet available to establish trends. Robinson et al. (2012) determined population structure and genetic diversity in the bluemask darter. They sampled bluemask darters in the Caney Fork, Collins and Rocky rivers and Cane Creek. Population genetic diversity and structure were assessed at ten microsatellite loci. All populations exhibited low levels of genetic variation, with expected heterozygosity ranging from 0.2 to 0.35 (USFWS, 2013).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2013)
Exposure:

Response:
Consequence:
Narrative: Operation of Great Falls Dam creates a barrier to movement of bluemask darters among the populations in the upper Caney Fork River, Cane Creek, Rocky River, and Collins River. It may also preclude movement of the fish into the Calfkiller River. Because the entire known range of the bluemask darter is being affected by operation of the dam and reservoir presence, this is considered the greatest threat to the continued existence and recovery of the species. Sedimentation from flow manipulations and impoundment effects is likely the second most significant threat to the bluemask darter. Wood and Armitage (1997) identified at least five impacts of sedimentation on fish, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency. There is speculation that water quality impacts from the City of Monterey's Wastewater Treatment Plant (WWTP) may have contributed to the apparent eradication of bluemask darters from the Calfkiller River. Additional threats to habitat include contaminants, water withdrawals, dredging, agricultural activities, logging, and impoundments (USFWS, 2013).

Stressor: Stochastic events (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: As indicated in the Recovery Plan (U.S. Fish and Wildlife Service 1997), existing bluemask darter populations inhabit only short stream reaches, rendering them vulnerable to extirpation from stochastic events, such as accidental toxic chemical spills. The Collins River Valley is used extensively for commercial plant nurseries, increasing the likelihood of a toxic agricultural chemical spill and contamination of stream substrate, which could impact that population of bluemask darters. Other sources of potential spills include accidents involving vehicles transporting chemicals over bridge crossings, or intentional releases into streams of chemicals used in agricultural or residential applications (USFWS, 2013).

Stressor: Isolated populations (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: As also indicated in the Recovery Plan, all existing bluemask darter populations are isolated due to the presence of the Great Falls Reservoir. While Robinson et al. (2012) indicate the low genetic diversity exhibited by the species may not have been the result of the impoundment, it is presumed that the existence of the reservoir does somewhat restrict gene flow among all the populations. Thus, the long-term genetic viability of bluemask darter populations is questionable. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007) (USFWS, 2013).

Recovery

Reclassification Criteria:

1. Through protection and enhancement of the existing populations, the species continues to exist in four rivers* and viable populations** exist in at least three of these rivers (USFWS, 2013).

2. Studies of the fish's biological and ecological requirements have been completed and the implementation of management strategies developed from these studies have been successful in substantially increasing the number and/or range of the bluemask darter in three rivers or additional collections or reintroduction efforts extend the darter's present known range to a fifth river* (e.g., Barren Fork or Mountain Creek) (USFWS, 2013).

3. No foreseeable threats exist that would likely impact the survival of the species over a significant portion of its range (USFWS, 2013).

Delisting Criteria:
1. Through the protection and enhancement of existing populations and successful establishment of reintroduced populations or discovery of additional populations, five distinct viable populations exist (USFWS, 2013).

2. Studies of the fish’s biological and ecological requirements have been completed and the implementation of management strategies developed from these studies have been successful in substantially increasing the number and/or range of the bluemask darter in four rivers (other than the Collins River) or additional collections or reintroduction efforts extend the species’ present known range to a total of at least six rivers (USFWS, 2013).

3. No foreseeable threats exist that would likely impact the survival of the species over a significant portion of its range (USFWS, 2013).

Recovery Actions:
- Use existing legislation/regulations to protect the species (USFWS, 1997).
- Determine threats and alleviate those that threaten the species’ existence (USFWS, 1997).
- Determine the species’ life history requirements (USFWS, 1997).
- Solicit the assistance of local landowners and initiate Partners for Wildlife projects to improve riparian habitat (USFWS, 1997).
- Develop and implement an information/education program (USFWS, 1997).
- Through augmentation or reintroduction, protect and establish viable populations (USFWS, 1997).
- Search for additional populations (USFWS, 1997).
- Determine whether it is feasible to reestablish the bluemask darter into its historic habitat. Layman et al. (1993) and Simmons (2004) both reported observing habitats in reaches above and below the City of Sparta that they believed to be suitable for reintroducing bluemask darters. The extant fish fauna in the Calfkiller River includes all darter species found in similar habitats throughout the Upper Caney Fork system, with the exception of the bluemask darter and possibly the corrugated darter (Etheostoma basilare), which may also no longer be part of the fish community based on recent surveys (J. W. Simmons, pers. comm. 2008; J. W. Simmons, pers. comm. 2013b). A thorough assessment of the distribution and quality of habitats in the Calfkiller should be prepared and a geospatial database developed, providing location data, ranking possible introduction sites according to relative

priority, and documenting threats observed within the watershed. Highest priority should be given to continuing to attempt locating suitable habitat upstream of the City of Sparta, in order to minimize the potential for water quality threats originating upstream of any sites chosen for reintroduction (USFWS, 2013).

- Investigate the potential for removal or notching of the following passage impediments on the Calfkiller River: - low-head dam located upstream of Hwy 70N that impounds the Calfkiller River downstream of the City of Sparta - check dam located in the vicinity of the City of Sparta's water intake - mill pond dam on the upper Calfkiller River Should attempts be made to establish a population in the Calfkiller River, removal of these dams would greatly improve potential for an introduced population to expand through natural dispersal processes (USFWS, 2013).
- Identify the appropriate broodstock selection and management strategies for reintroductions into the Calfkiller River, should this recovery action be implemented (USFWS, 2013).
- Establish a captive propagation program, if it is determined that existing populations could not function as a source of individuals for reintroduction into the Calfkiller River. Prior to doing so, review existing population genetics data to determine whether they provide a sufficient basis for developing a broodstock management plan. If additional genetics studies are necessary, conduct them prior to initiating captive propagation efforts (USFWS, 2013).
- Conduct life history studies in concert with any captive propagation efforts (USFWS, 2013).
- Continue TVA's population and habitat monitoring. Evaluate data produced by this monitoring in conjunction with Simmons (2004) data from the monitoring stations to determine what level of change could be detected by these efforts. These efforts would incorporate any newly discovered, introduced or expanded population segments (USFWS, 2013).
- Use existing state and federal regulations and develop partnerships (local watershed projects) with federal and state agencies, local governments, nurserymen, farming groups, coal mining interests, conservation organizations, and local landowners and individuals to protect the species and its essential habitat (USFWS, 2013).
- Ensure that all collection data are represented by records in the databases maintained by TVA's Regional Natural Heritage Project and Tennessee Division of Natural Areas' – Natural Heritage program. These databases are used during environmental reviews to screen for the presence of threatened and endangered species, and it is critical that both programs are continually provided the most current data from studies, as well as from TVA's ongoing bluemask darter monitoring (USFWS, 2013).
- Identify important non-point sources of sediment in the drainages occupied by bluemask darters to prioritize areas for working with private landowners to reduce such threats. Additionally, identify major landowners in the drainages occupied by bluemask darters who should be targeted for cooperative conservation efforts to prevent future risk of erosion and sedimentation associated with anticipated land uses (USFWS, 2013).
- Conduct water quality studies in the Calfkiller River and compare results to similar sampling results, obtained where known bluemask darter populations occur in the Collins River, to assist in determining why bluemask darters no longer occur in the Calfkiller. Continue to conduct fish IBI sampling in conjunction with water quality monitoring (USFWS, 2013).
- Engage the City of Crossville in developing water supply alternatives that would meet projected future water needs for this community without requiring any new impoundments in the Upper Caney Fork system (USFWS, 2013).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Continue to propagate and reintroduce bluemask darters into the Calfkiller River. To ensure that the species has the best chance of survival and reestablishment in the Calfkiller River, such reintroductions should be supported by the data generated by the TTU study that quantitatively analyzes the ecological requirements of the bluemask darter at multiple spatial scales. • Additional efforts should be undertaken regarding removal or notching of the following passage impediments on the Calfkiller River: (1) The low-head dam upstream of TN Hwy 70N downstream of the City of Sparta; (2) The check dam located near the City of Sparta's water intake; and (3) The mill pond dam on the upper Calfkiller River. • Continue to review bluemask darter population genetics data to determine the most appropriate brood source for reestablishment of a Calfkiller River population. If additional genetics studies are necessary, conduct those studies as necessary. • TVA's population and habitat monitoring should continue. The data produced by this monitoring should be evaluated in conjunction with Simmons' (2004) data from the monitoring stations to determine the level of change that can be detected by these efforts. These efforts should incorporate any newly discovered, introduced, or expanded population segments. • Conduct a study to determine if juvenile bluemask darters found in the inundated lower reach of the Rocky River are contributing to the Rocky River population and if these individuals are surviving to breed. • Use available resources and partnerships to address threats, protect the species, and conserve its habitat. • Ensure that all collection data are provided to TVA's Regional Natural Heritage Project and the Tennessee Division of Natural Areas' Natural Heritage program. • Water quality studies and additional fish IBI sampling should be conducted in the Calfkiller River to determine the sources and types of water quality impairments that may limit the species in the watershed. If it is determined that the Monterey Waste Water Treatment Plant is negatively affecting the species, focus available resources and partnerships to assist the City of Monterey with efforts to rectify the issue. • Follow-up surveys in the two, previously-surveyed Collins River stream reaches should be conducted to verify actual water withdrawal sites (USFWS, 2020)

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SPECIES ACCOUNT: *Etheostoma spilotum* (Kentucky arrow darter)

Species Taxonomic and Listing Information

Listing Status: Threatened; 11/04/2016; Southeast Region (R4) (USFWS, 2016)

Physical Description

The Kentucky arrow darter, Etheostoma spilotum Gilbert, is a rather large darter reaching 116 millimeters (mm) (4.6 inches [in]) total length (TL) (Kuehne and Barbour 1983, p. 71; Etnier and Starnes 1993, p. 523). It has a slender body, elongated snout, large mouth, and virtually scaleless head. The species ground color is straw yellow to pale greenish, and the back is crossed by 5 to 7 weak dorsal saddles, some of which may fuse with the 8 to 11 vertical lateral blotches (Kuehne and Barbour 1983, p. 71; Etnier and Starnes 1993, p. 523). Anterior blotches are generally oval with pale centers. Posteriorly, blotches extend ventrally almost to the midline and may resemble the letters N, W, U, or V. A dark vertical bar occurs at the base of the caudal fin, sometimes separated by two distinct spots. The belly is pale (Kuehne and Barbour 1983, p. 71). During the spawning season, breeding males exhibit vibrant coloration. Most of the body is blue-green in color, with scattered scarlet spots and scarlet to orange vertical bars laterally; the vertical bars can be connected ventrally by an orange belly stripe (Etnier and Starnes 1993, p. 523). The spinous dorsal fin exhibits a blue-green central band and a scarlet marginal band. The soft dorsal and caudal fins are speckled with scarlet blotches or bands, and the anal and pelvic fins are blue-green to black. Females remain pale straw yellow with grayish markings (Etnier and Starnes 1993, p. 523). (USFWS, 2013)

Taxonomy

The Kentucky arrow darter was described from the Kentucky River basin (Sturgeon Creek, Owsley County) as Etheostoma nianguae spilotum (Gilbert 1887, pp. 53-54). Bailey (1948, pp. 80-84) redescribed the species, placing it and its closest relatives, P. nianguae (Gilbert and Meek) and P. sagitta (Jordan and Swain), in a new subgenus, Litocara. Subsequent to this, Bailey et al. (1954, pp. 109-164) and Bailey and Gosline (1955, pp. 1-44) synonymized (combined taxonomically) Poecilichthys with the genus Etheostoma and Litocara with the subgenus Oligocephalus, in which E. spilotum and its relatives were regarded as a species group (group of closely related species within a genus that are grouped because they are morphologically similar and share a common ancestory). Kuehne and Bailey (1961, pp. 1-5) evaluated new material for all three members of Oligocephalus and determined that the group consisted of two species, E. nianguae (Gilbert and Meek) and E. sagitta (Jordan and Swain), and three forms. Etheostoma nianguae was distinctive morphologically and confined to the lower Osage River system in Missouri. Etheostoma sagitta was recognized as a polytypic species (represented by more than one subspecies), consisting of E. s. sagitta, an endemic form to the upper Cumberland River system, and E. sagitta spilotum (Kentucky arrow darter), an endemic form to the upper Kentucky River system. The subgenus Litocara was later resurrected (reinstated taxonomically) by Page and Whitt (1973, pp. 611-623) to include E. nianguae Gilbert and Meek and E. sagitta (Jordan and Swain). Subsequently, the Kentucky arrow darters subspecific status was supported by Kuehne and Barbour (1983, p. 71), Page (1983, p. 59), and Etnier and Starnes (1993, p. 523). Thomas (2008, p. 6) questioned the polytypic status of E. sagitta by arguing that (1) the two subspecies were distinguishable based on scale size and the development of the lateral line (see note below), (2) the two subspecies existed in allopatry (separate ranges with no overlap), (3) the two subspecies lacked intergrades (intermediate forms), and (4) unpublished genetic data (mitochondrial DNA) suggested evolutionary independence of Kentucky and Cumberland basin populations (with no recent genetic exchange). Based on these analyses and additional morphological and genetic evidence presented by Thomas and Johansen (2008, p. 46), the two arrow darter subspecies have been elevated to species rank (Page and Burr 2011, p. 569; Eschmeyer 2013). The Cumberland arrow darter, E. sagitta (Jordan and Swain) is restricted to the upper Cumberland River basin, and the Kentucky arrow darter, E. spilotum Gilbert, is restricted to the upper Kentucky River basin. *Note: Cumberland and Kentucky arrow darters are indistinguishable based on general appearance, including pigment pattern and breeding color; however, the two species are separable based on various scale counts. Thomas (2008, p. 6) examined specimens of both species and determined that the Kentucky arrow darter had lateral scale counts of 62 or fewer in 88% of individuals examined (vs. 63 or more in 94% of Cumberland arrow darters), pored lateral scale counts of 50 or fewer in 79% of individuals examined (vs. 51 or more in 91% of Cumberland arrow darters), and caudal peduncle scale counts of 22 or fewer in 72% of individuals examined (vs. 23 or more in 83% of Cumberland arrow darters). These differences reflect a trend toward larger scale size and a more weakly developed lateral line (a faint line of sense organs extending from the gill cover to the tail) in the Kentucky arrow darter. (USFWS, 2013)

Historical Range

The Kentucky arrow darters historical distribution was limited to the upper Kentucky River system in eastern Kentucky (Kuehne and Bailey 1961, pp. 3-4; Kuehne 1962, pp. 608-609; Lotrich 1973, p. 380; Branson and Batch 1983, pp. 1-15; Burr and Warren 1986, p. 316; Ray and Ceas 2003, pp. 1-15). Its distribution spanned portions of five subbasins: Red River (Rockbridge Fork of Swift Camp Creek), Sturgeon Creek, South Fork Kentucky River, Middle Fork Kentucky River, and North Fork Kentucky River (Thomas 2008, p. 3). (USFWS, 2013)

Current Range

The Kentucky arrow darter continues to occupy portions of the upper Kentucky River basin in eastern Kentucky, including the five sub-basins listed above; however, recent surveys by Thomas (2009, pp. 3-6) and the U.S. Fish and Wildlife Service (USFWS 2009, pp. 1-4; 2010,pp. 1-13) revealed that the Kentucky arrow darter has disappeared from portions of its range. The species was observed at only 34 of 68 historic streams (50 percent) and 45 of 100 historic sites (46 percent) during surveys completed from 2007 to 2010 (Thomas 2009, pp. 3-6; USFWS 2009, pp. 1-4; USFWS 2010, pp. 1-13). In 2010, additional surveys were initiated by the KFO within the Kentucky arrow darters historic range but in streams lacking previous records for the subspecies (USFWS 2010, pp. 1-13). A total of 14 new streams were surveyed across the basin, but no Kentucky arrow darters were observed. (USFWS, 2013)

Distinct Population Segments Defined

Not applicable

Critical Habitat Designated

Yes; 10/5/2016.

Legal Description

On October 5, 2016, the U.S. Fish and Wildlife Service (Service), designated critical habitat for the Kentucky arrow darter (Etheostoma spilotum) under the Endangered Species Act, as amended (81 FR 69312 - 69363). In total, approximately 398 stream kilometers (skm) (248 stream miles (smi)) fall within the boundaries of the critical habitat designation.

Critical Habitat Designation

The crtical habitat designation for Etheostoma spilotum includes 38 units totaling approximately 398 skm (248 smi) in Breathitt, Clay, Harlan, Jackson, Knott, Lee, Leslie, Owsley, Perry, and Wolfe Counties, Kentucky.

Unit 1: Buckhorn Creek and Prince Fork, Knott County, Kentucky. Unit 1 is located off Buckhorn Road in the headwaters of the Buckhorn Creek drainage and between Kentucky Highway 1098 (KY 1098) and KY 1087. It includes 0.7 skm (0.4 smi) of Prince Fork from its confluence with Mart Branch downstream to its confluence with Buckhorn Creek and 0.4 skm (0.3 smi) of Buckhorn Creek from its confluence with Prince Fork downstream to its confluence with Emory Branch. Live Kentucky arrow darters have been collected from Unit 1 in Prince Fork and just upstream of the confluence of Buckhorn Creek and Emory Branch (ATS 2011, p. 6; Service 2012, pp. 1–4). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The watershed surrounding Unit 1 is dominated by forest and remains relatively undisturbed; however, downstream reaches of Buckhorn Creek have been degraded by siltation and nonpointsource pollutants associated with surface coal mining, oil and gas exploration, logging, and runoff from unpaved roads (Service 2012, pp. 1–4). Within Unit 1, the physical and biological features may require special management considerations or protection to address potential adverse effects (e.g., water pollution, siltation) associated with surface coal mining, logging (timber harvests on private land), natural gas and oil exploration, construction and maintenance of county roads (Buckhorn Road), the lack of adequate riparian buffers (near the confluence with Emory Branch), and off-road vehicle use. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species (adds population redundancy), and provides opportunity for population growth.

Unit 2: Eli Fork, Knott County, Kentucky. This unit is located in the headwaters of the Buckhorn Creek drainage between KY 1098 and KY 1087. It includes 1.0 skm (0.6 smi) of Eli Fork from its confluence with Stonecoal Branch downstream to its confluence with Boughcamp Branch (of Buckhorn Creek). Live Kentucky arrow darters have been collected from Unit 2 near the confluence of Eli Fork and Boughcamp Branch (ATS 2011, p. 6). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The watershed surrounding Unit 2 is dominated by forest and remains relatively undisturbed; however, its receiving stream, Boughcamp Branch, and adjacent watersheds have been degraded by siltation and nonpointsource pollutants associated with surface coal mining and logging (Service 2012, pp. 1–4). Within Unit 2, the physical and biological features may require special management considerations or protection to address potential adverse effects (e.g., water pollution, siltation) associated with surface coal mining, logging, natural gas and oil exploration, off-road vehicle use, and construction and maintenance of county roads. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species (adds population redundancy), and provides opportunity for population growth.

Unit 3: Coles Fork and Snag Ridge Fork, Breathitt and Knott Counties, Kentucky. This unit is located entirely within Robinson Forest, a 4,047-hectare (10,000-acre) research, education, and extension forest in Breathitt and Knott Counties owned by UK and managed by the Department of Forestry in the College of Agriculture, Food, and Environment. Unit 3 includes 2.1 skm (1.3 smi) of Snag Ridge Fork from its headwaters downstream to its confluence with Coles Fork and 8.9 skm (5.5 smi) of Coles Fork from its confluence with Saddle Branch downstream to its confluence with Buckhorn Creek. Live Kentucky arrow darters have been observed throughout Unit 3 (Thomas 2008, p. 5; Service 2012, pp. 1–4), and Coles Fork continues to be one of the species' best remaining habitats. This unit is located entirely on lands owned by UK. The watershed surrounding Unit 3 is intact and densely forested, water quality conditions are excellent (very close to baseline levels), and instream habitats are ideal for the species. Within Unit 3, the physical and biological features may require special management considerations or protection to address siltation associated with timber management (on Robinson Forest) and stormwater runoff from unpaved roads; however, we consider these threats to be minor as management activities and general use of Robinson Forest over the last 40 years have been consistent with the maintenance of Kentucky arrow darter populations in the Clemons Fork watershed. These minor threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, represents a stronghold for the species (core population), and likely contributes to range expansion (source population).

Unit 4: Clemons Fork, Breathitt County, Kentucky. Unit 4 is located along Clemons Fork Road in southeastern Breathitt County. This unit includes 7.0 skm (4.4 smi) of Clemons Fork from its confluence with Maple Hollow downstream to its confluence with Buckhorn Creek. Live Kentucky arrow darters have been observed throughout Unit 4 (Lotrich 1973, p. 380; Thomas 2008, p. 5; Service 2012, pp. 1–4). A portion of this unit near the mouth of Clemons Fork is privately owned (0.1 skm (0.1 smi)), but the majority is located on lands owned by UK (see description for Unit 3). The watershed surrounding Unit 4 is intact and densely forested, water quality conditions are excellent (very close to baseline levels), and instream habitats are ideal for the species. Clemons Fork continues to be one of the species' best remaining habitats. Within Unit 4, the physical and biological features may require special management considerations or protection to address siltation associated with timber management (on Robinson Forest) and stormwater runoff from unpaved roads; however, we consider these threats to be minor as management activities and general use of Robinson Forest over the last 40 years have been consistent with the maintenance of Kentucky arrow darter populations in the Clemons Fork watershed. These minor threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, represents a stronghold for the species (core population), and likely contributes to range expansion (source population).

Unit 5: Laurel Fork Quicksand Creek and Tributaries, Knott County, Kentucky. Unit 5 generally runs parallel to KY 1098 and Laurel Fork Road in northern Knott County. This unit includes 1.2 skm (0.8 smi) of Fitch Branch from its headwaters downstream to its confluence with Laurel Fork Quicksand Creek, 2.7 skm (1.7 smi) of Newman Branch from its headwaters downstream to its confluence with Laurel Fork Quicksand Creek, 2.1 skm (1.3 smi) of Combs Branch from its headwaters downstream to its confluence with Laurel Fork Quicksand Creek, and 13.8 skm (8.6 smi) of Laurel Fork Quicksand Creek from KY 80 downstream to its confluence with Patten Fork. Live Kentucky arrow darters have been captured within Unit 5 just upstream of the Laurel Fork and Patten Fork confluence and farther upstream at the first Laurel Fork Road crossing (Thomas 2008, p. 5; Service 2012, pp. 1–4). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. Hillsides and ridgetops above Unit 5 are forested, but the valley is more developed with scattered residences along Laurel Fork Road. Within Unit 5, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with logging, inadequate sewage treatment, surface coal mining, natural gas and oil exploration activities, inadequate riparian buffers, construction and maintenance of county roads, and off-road vehicle use. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species (adds population redundancy), and likely serves as a source population within the Quicksand Creek watershed.

Unit 6: Middle Fork Quicksand Creek and Tributaries, Knott County, Kentucky. Unit 6 is located along Middle Fork of Quicksand Creek Road in northeastern Knott County. This unit includes 0.8 skm (0.5 smi) of Big Firecoal Branch from its headwaters downstream to its confluence with Middle Fork Quicksand Creek, 2.1 skm (1.3 smi) of Bradley Branch from its headwaters downstream to its confluence with Middle Fork Quicksand Creek, 2.0 skm (1.2 smi) of Lynn Log Branch from its headwaters downstream to its confluence with Middle Fork Quicksand Creek, and 20.3 skm (12.6 smi) of Middle Fork Quicksand Creek from its headwaters downstream to its confluence with Quicksand Creek. Live Kentucky arrow darters have been captured within Unit 6 near the confluence of Middle Fork and Jack Branch, the confluence of Middle Fork and Upper Bear Pen Branch, and near the confluence of Middle Fork and Quicksand Creek (Thomas 2008, p. 5; Service 2012, pp. 1– 4; Eisenhour pers. comm. 2015). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The watershed surrounding Unit 6 is dominated by forest and continues to be relatively undisturbed. An unpaved road traverses the length of the unit, but the rough condition of the road limits its use to off-road vehicles. Within Unit 6, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with natural gas and oil exploration activities, logging, surface coal mining, inadequate riparian buffers, construction and maintenance of county roads, and off-road vehicle use. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species (adds population redundancy), and likely serves as a source population within the Quicksand Creek watershed.

Unit 7: Spring Fork Quicksand Creek, Breathitt County, Kentucky. Unit 7 is located off KY 2465 in southeastern Breathitt County and includes 2.2 skm (1.4 smi) of Spring Fork Quicksand Creek from its headwaters downstream to its confluence with an unnamed tributary. Live Kentucky arrow darters have been captured within Unit 7 (Service unpublished data). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. Most of the watershed surrounding Unit 7 is forested, but mine reclamation activities have created open, pasture-like habitats along ridgetops and slopes to the north. Within Unit 7, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with surface coal mining, natural gas and oil exploration activities, logging, and off-road vehicle use. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species within the Quicksand Creek watershed (adds population redundancy), and provides opportunity for population growth.

Unit 8: Hunting Creek and Tributaries, Breathitt County, Kentucky. Unit 8 is located along KY 1094 in eastern Breathitt County and includes 0.9 skm (0.5 smi) of Wolf Pen Branch from its headwaters downstream to its confluence with Hunting Creek, 2.3 skm (1.4 smi) of Fletcher Fork from its headwaters downstream to its confluence with Hunting Creek, 1.6 skm (1.0 smi) of Negro Fork from its headwaters downstream to its confluence with Hunting Creek, 3.1 skm (1.9 smi) of Licking Fork from its headwaters downstream to its confluence with Hunting Creek, and 7.7 skm (4.8 smi) of Hunting Creek from its confluence with Wells Fork downstream to its confluence with Quicksand Creek. Live Kentucky arrow darters have been captured within Unit 8 near the confluence with Winnie Branch (Service unpublished data). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The narrow valley surrounding Unit 8 contains a few scattered residences and fields along Hunting Creek Road, but the majority of the watershed is relatively intact and dominated by forest. Within Unit 8, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with natural gas and oil exploration activities, logging, surface coal mining, inadequate sewage treatment, inadequate riparian buffers, construction and maintenance of county roads, and off-road vehicle use. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species within the Quicksand Creek watershed (adds population redundancy), and provides opportunity for population growth.

Unit 9: Frozen Creek and Tributaries, Breathitt County, Kentucky. Unit 9 is located along KY 378 in northern Breathitt County. This unit includes 4.7 skm (2.9 smi) of Clear Fork from its headwaters downstream to its confluence with Frozen Creek, 3.6 skm (2.3 smi) of Negro Branch from its headwaters downstream to its confluence with Frozen Creek, 4.2 skm (2.6 smi) of Davis Creek from its headwaters downstream to its confluence with Frozen Creek, and 13.9 skm (8.6 smi) of Frozen Creek from its headwaters downstream to its confluence with Morgue Fork. Live Kentucky arrow darters have been captured within Unit 9 upstream of Rock Lick in the headwaters of Frozen Creek (Thomas 2008, p. 5; Service unpublished data). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The individual valleys surrounding Unit 9 are relatively narrow (approximately 100–160 meters (m) (328–525 feet (ft)) at their widest) and composed of small farms and scattered residences. The ridgetops and hillsides are relatively undisturbed and dominated by forest. Within Unit 9, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with inadequate sewage treatment, canopy loss, agricultural runoff, inadequate riparian buffers, construction and maintenance of county roads, logging, natural gas and oil exploration activities, surface coal mining (legacy effects), and off-road vehicle use. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species (adds population redundancy), contributes to genetic exchange between several streams in the Frozen Creek watershed, and likely serves as an important source population in the northern limits of the species' range.

Unit 10: Holly Creek and Tributaries, Wolfe County, Kentucky. Unit 10 is located along KY 1261 in southern Wolfe County and includes 2.8 skm (1.8 smi) of Spring Branch from its headwaters downstream to its confluence with Holly Creek, 2.0 skm (1.3 smi) of Pence Branch from its headwaters downstream to its confluence with Holly Creek, 4.0 skm (2.5 smi) of Cave Branch from its headwaters downstream to its confluence with Holly Creek, and 9.5 skm (5.9 smi) of Holly Creek from KY 1261 (first bridge crossing north of KY 15) downstream to its confluence with the North Fork Kentucky River. Live Kentucky arrow darters have been captured within Unit 10 near the confluence of Holly Creek and Spring Branch (Thomas 2008, p. 5). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The valley bottom surrounding Unit 10 is consistently wider (approximately 320 m (1,050 ft) at its widest) than other occupied stream valleys (e.g., Frozen Creek), and agricultural land use is more extensive. Multiple small farms (e.g., pasture, row crops, hayfields) and residences are scattered along KY 1261, while the ridgetops and hillsides are dominated by forest. The Service is not designating critical habitat in upstream reaches of the drainage (e.g., Kelse Holland Fork, Mandy Holland Fork, Terrell Fork) because these streams do not contain the PCEs essential to the species’ conservation. Habitat conditions in these upstream reaches are poor, as characterized by straightened, incised channels; a lack of canopy cover; and unstable substrates. Within Unit 10, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with agricultural runoff, canopy loss, inadequate riparian buffers, construction and maintenance of county roads, inadequate sewage treatment, logging, surface coal mining (legacy effects), and off-road vehicle use. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species, and provides opportunity for population growth.

Unit 11: Little Fork, Lee and Wolfe Counties, Kentucky. This unit is located between KY 2016 and Booth Ridge Road in southern Wolfe County and includes 3.8 skm (2.3 smi) of Little Fork from its headwaters downstream to its confluence with Lower Devil Creek. Live Kentucky arrow darters have been captured within Unit 11 just upstream of the confluence of Little Fork and Lower Devil Creek (Thomas 2008, p. 5; Service 2012, pp. 1– 4). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The valley bottom surrounding this unit is densely forested, but a network of unpaved roads and oil and gas well sites are located along the ridgetops to the east and west of the stream. Within Unit 11, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with oil and gas exploration activities, off-road vehicle use, road runoff, canopy loss, logging, and surface coal mining (legacy effects). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species (population redundancy), and provides opportunity for population growth.

Unit 12: Walker Creek and Tributaries, Lee and Wolfe Counties, Kentucky. Unit 12 is located between KY 11 and Shumaker Road to the west and KY 2016 to the east in northern Lee County and southwestern Wolfe County. This unit includes 3.9 skm (2.4 smi) of an unnamed tributary of Walker Creek from its headwaters downstream to its confluence with Walker Creek, 2.4 skm (1.5 smi) of Cowan Fork from its headwaters downstream to its confluence with Hell for Certain Creek, 2.0 skm (1.2 smi) of Hell for Certain Creek from the outflow of an unnamed reservoir downstream to its confluence with Walker Creek, 0.8 skm (0.5 smi) of Boonesboro Fork from its headwaters downstream to its confluence with Walker Creek, 2.2 skm (1.4 smi) of Peddler Creek from its headwaters downstream to its confluence with Walker Creek, 1.1 skm (0.7 smi) of Huff Cave Branch from its headwaters downstream to its confluence with Walker Creek, and 12.6 skm (7.8 smi) of Walker Creek from its headwaters (reservoir) downstream to its confluence with North Fork Kentucky River. Live Kentucky arrow darters have been captured at several locations within Unit 12 (Thomas 2008, p. 5; Service 2012, pp. 1–4), including the Old Fincastle Road low-water crossing, a site upstream near the confluence with Boonesboro Fork, and in the headwaters just upstream of the confluence of Walker Creek with Hell For Certain Creek. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. Land use surrounding this unit is similar to that of Little Fork (Unit 11) and Hell Creek (Unit 13). The valley bottom is densely forested, but numerous unpaved roads, oil and gas well sites, and scattered residences occur along the ridgetops to the east and west of the stream. A narrow, unmaintained dirt road (Walker Creek Road) runs parallel to and east of this unit for its entire length; off-road vehicle use is common. Within Unit 12, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with oil and gas exploration activities, off-road vehicle use, road runoff, canopy loss, and legacy effects of previous oil and gas well development. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species (adds population redundancy), contributes to genetic exchange between several streams in the Walker Creek watershed, and likely serves as an important source population in the northern limits of the species' range.

Unit 13: Hell Creek and Tributaries, Lee County, Kentucky. Unit 13 is located between KY 11 and Shumaker Road in northern Lee County. This unit includes 2.3 skm (1.4 smi) of Miller Fork from its headwaters downstream to its confluence with Hell Creek, 0.7 skm (0.4 smi) of Bowman Fork from its headwaters downstream to its confluence with Hell Creek, 1.9 skm (1.2 smi) of an unnamed tributary of Hell Creek from its headwaters downstream to its confluence with Hell Creek, and 7.1 skm (4.4 smi) of Hell Creek from the outflow of an unnamed reservoir downstream to its confluence with North Fork Kentucky River. Live Kentucky arrow darters have been captured within Unit 13 from the Hell Creek mainstem near the Hell Creek Road low-water crossing and from an unnamed triburary of Hell Creek near the Hell Creek Road low-water crossing (Thomas 2008, p. 5; Service 2012, pp. 1– 4). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. Land use surrounding this unit is similar to that of Little Fork (Unit 11) and Walker Creek (Unit 12). The valley bottom surrounding this unit is forested, but numerous unpaved roads, oil and gas well sites, and scattered residences occur along the ridgetops to the east and west of the stream. A narrow, unmaintained dirt road runs parallel to and east of Unit 13 upstream of the Hell Creek Road crossing; off-road vehicle use is common. Within Unit 13, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with oil and gas exploration activities, off-road vehicle use, road runoff, canopy loss, and legacy effects of previous oil and gas well development. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species (population redundancy), and provides opportunity for population growth.

Unit 14: Big Laurel Creek, Harlan County, Kentucky. Unit 14 is located off KY 221 and Big Laurel Creek Road in northern Harlan County and includes 9.1 skm (5.7 smi) of Big Laurel Creek from its confluence with Combs Fork downstream to its confluence with Greasy Creek. Live Kentucky arrow darters have been captured from this unit near its confluence with White Oak Branch (Thomas 2008, p. 5; Service 2012, pp. 1– 4). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The valley bottom and hillsides surrounding Unit 14 are densely forested, but extensive surface coal mining within the watershed has created clearings along the ridgetops and has resulted in five valley (hollow) fills that are located within tributaries of Big Laurel Creek. Within Unit 14, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with historical surface coal mining, off-road vehicle use, road runoff, logging, and canopy loss. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding and adds population redundancy at the southeastern edge of the species' range.

Unit 15: Laurel Creek, Leslie County, Kentucky. Unit 15 is located south of US 421/KY 80 in western Leslie County and includes 4.1 skm (2.6 smi) of Laurel Creek from its confluence with Sandlick Branch downstream to its confluence with Left Fork Rockhouse Creek. A single live Kentucky arrow darter has been captured from this unit, approximately 0.48 skm (0.3 smi) from the confluence with Left Fork Rockhouse Creek (Thomas 2013, pers. comm.). A small portion of this unit is privately owned (0.7 skm (0.5 smi)), but the remainder of the unit is in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 15 is entirely forested, with no private residences or other structures. Within Unit 15, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with illegal off-road vehicle use, road runoff, and timber management. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, adds population redundancy, and provides opportunity for population growth.

Unit 16: Hell For Certain Creek and Tributaries, Leslie County, Kentucky. Unit 16 is located off Hell For Certain Road between KY 1482 and KY 257 in northern Leslie County. This unit includes 1.3 skm (0.8 smi) of Cucumber Branch from its headwaters downstream to its confluence with Hell For Certain Creek, 3.1 skm (1.9 smi) of Big Fork from its headwaters downstream to its confluence with Hell For Certain Creek, and 11.4 skm (7.1 smi) of Hell For Certain Creek from its headwaters downstream to its confluence with Middle Fork Kentucky River. Live Kentucky arrow darters have been captured from Unit 16 at multiple locations upstream of its confluence with Big Fork (Thomas 2008, p. 4; Service unpublished data). A portion of this unit is in Federal ownership (administered by DBNF) (4.4 skm (2.8 smi)), but the majority of the unit is in private ownership. For the portion of the unit in Federal ownership, land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1– 14). The valley bottom surrounding Unit 16 is narrow (approximately 100 m (328 ft) at its widest) and composed of a mixture of small farms (e.g., pasture, hayfields) and scattered residences along Hell For Certain Road. The ridgetops and hillsides are relatively undisturbed and dominated by forest. Within Unit 16, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, inadequate sewage treatment, inadequate riparian buffers, construction and maintenance of county roads, agricultural runoff, illegal off-road vehicle use, logging, and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, represents a stronghold for the species within the Middle Fork Kentucky River sub-basin, and likely acts as a source population. This unit is also important for maintaining the distribution and genetic diversity of the species within the Middle Fork sub-basin.

Unit 17: Squabble Creek, Perry County, Kentucky. This unit is located south of KY 28, just downstream of Buckhorn Lake Dam and near the community of Buckhorn in northwestern Perry County. Unit 17 includes 12.0 skm (7.5 smi) of Squabble Creek from its confluence with Long Fork downstream to its confluence with Middle Fork Kentucky River. Live Kentucky arrow darters have been captured from this unit near its confluence with Big Branch (Service unpublished data). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The valley surrounding Unit 17 is narrow (approximately 113 m (370 ft) at its widest) and composed of a mixture of residences (many in clusters) and small farms (e.g., pasture, hayfields) scattered along KY 2022, which parallels Squabble Creek for much of its length. Ridgetops and hillsides in most of the Squabble Creek valley are relatively undisturbed and dominated by forest; however, surface coal mining has occurred along ridgetops (to the north and south of Squabble Creek) in the downstream half of the drainage. Within Unit 17, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, inadequate sewage treatment, agricultural runoff, inadequate riparian buffers, construction and maintenance of county roads, illegal off-road vehicle use, logging, and historical surface coal mining. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species, and provides opportunity for population growth.

Unit 18: Blue Hole Creek and Left Fork Blue Hole Creek, Clay County, Kentucky. Unit 18 is located along KY 1524 in southeastern Clay County. This unit includes 1.8 skm (1.1 smi) of Left Fork from its headwaters downstream to its confluence with Blue Hole Creek and 3.9 skm (2.4 smi) of Blue Hole Creek from its confluence with Dry Branch downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured from Unit 18 near the mouth of Cow Hollow (Thomas 2008, p. 4). This unit is entirely in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 18 is entirely forested, with no private residences or other structures. The only interruption in the canopy is the KY 1525 corridor, which traverses most of the valley. One additional road, Blue Hole School Road, is located at the headwaters of Blue Hole Creek, leading to a small cemetery site. Blue Hole Creek is 1 of 11 Red Bird River tributaries (Units 18–28) that support Kentucky arrow populations (Thomas 2008, entire; Service 2012, entire). Collectively, these streams represent the largest, most significant cluster of occupied streams and are characterized by intact riparian zones with negligible residential development, high gradients with abundant riffles, cool temperatures, low conductivities (less than 100 mS/cm), and stable channels with clean cobble and boulder substrates (Thomas 2008, p. 4; Service 2014, p. 6). Within Unit 18, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, illegal offroad vehicle use, and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 19: Upper Bear Creek and Tributaries, Clay County, Kentucky. Unit 19 is located along KY 1524 and Upper Bear Creek Road in southeastern Clay County. This unit includes 1.5 skm (1.0 smi) of Left Fork Upper Bear Creek from its headwaters downstream to its confluence with Upper Bear Creek, 0.8 skm (0.5 smi) of Right Fork Upper Bear Creek from its headwaters downstream to its confluence with Upper Bear Creek, and 4.5 skm (2.8 smi) of Upper Bear Creek from its confluence with Left Fork and Right Fork Upper Bear Creek downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured from Unit 19 in two locations downstream of the Left and Right Forks (Thomas 2008, p. 4). A small portion of this unit is privately owned (0.2 skm (0.1 smi)), but the majority of the unit is in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 19 is primarily forested, but a few scattered residences and small farms are located along KY 1524 in the upstream (western) half of the watershed. Upper Bear Creek is 1 of 11 Red Bird River tributaries (Units 18–28) that support Kentucky arrow populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 19, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, illegal offroad vehicle use, agricultural runoff, and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 20: Katies Creek, Clay County, Kentucky. Unit 20 is located along Katies Creek Road in southeastern Clay County and includes 5.7 skm (3.5 smi) of Katies Creek from its confluence with Cave Branch downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured from this unit approximately 0.2 skm (0.12 smi) upstream of the mouth of Katies Creek (Thomas 2008, p. 4). A small portion of this unit is privately owned (1.7 skm (1 smi)), but the majority of the unit is in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1– 14). The watershed surrounding Unit 20 is entirely forested, with no private residences or other structures. The only interruption in the canopy is the Katies Creek Road corridor, which traverses the valley. Katies Creek is 1 of 11 Red Bird River tributaries (Units 18–28) that support Kentucky arrow populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 20, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, illegal offroad vehicle use, logging (on private land), and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 21: Spring Creek and Little Spring Creek, Clay County, Kentucky. Unit 21 is located west of KY 66 in southeastern Clay County. This unit includes 1.0 skm (0.6 smi) of Little Spring Creek from its headwaters downstream to its confluence with Spring Creek and 8.2 skm (5.1 smi) of Spring Creek from its headwaters downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured within Unit 21 approximately 0.2 skm (0.1 smi) upstream of the mouth of Spring Creek (Thomas 2008, p. 4). A portion of this unit is privately owned (3.6 skm (2.2 smi)), but the majority of the unit is in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF’s LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 21 is relatively undisturbed and dominated by forest; however, a few scattered residences are located along a short segment (approximately 0.8 skm (0.5 smi)) of Lower Spring Creek Road near its junction with KY 66 and along Sand Hill Road and Spring Creek Road at the western (upstream) end of the drainage. The stream corridor between these two areas, an approximate 6.4-skm (4-smi) segment, is inaccessible except by offroad vehicle. About 10 oil wells are located along ridgetops and hillsides near the mouth of Spring Creek, and these sites are connected by a network of unpaved roads. Spring Creek is 1 of 11 Red Bird River tributaries (Units 18– 28) that support Kentucky arrow populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 21, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, off-road vehicle use, inadequate sewage treatment, logging (on private land), timber management (on DBNF), and oil and gas exploration activities. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species’ core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 22: Bowen Creek and Tributaries, Leslie County, Kentucky. Unit 22 is located east of KY 66 and adjacent to Bowen Creek Road in western Leslie County. This unit includes 2.2 skm (1.4 smi) of Laurel Fork from its headwaters downstream to its confluence with Bowen Creek, 1.8 skm (1.1 smi) of Amy Branch from its headwaters downstream to its confluence with Bowen Creek, and 9.6 skm (6.0 smi) of Bowen Creek from its headwaters downstream to the Red Bird River. Live Kentucky arrow darters have been captured from Unit 22 near its confluence with Blevins Branch and Hurricane Branch (Service unpublished data). A portion of this unit is privately owned (2.0 skm (1.2 smi)), but the majority of the unit is in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF’s LRMP (USFS 2004, pp. 1–14). The watershed surrounding this unit is relatively undisturbed and dominated by forest. A few scattered residences are located along Bowen Creek Road near the mid-point of the valley, and others are located further upstream along KY 406. Bowen Creek is 1 of 11 Red Bird River tributaries (Units 18–28) that support Kentucky arrow darter populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 22, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, illegal offroad vehicle use, inadequate sewage treatment, logging (on private land), and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species’ core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 23: Elisha Creek and Tributaries, Leslie County, Kentucky. Unit 23 is located east of KY 66 and adjacent to Elisha Creek Road in western Leslie County. This unit includes 4.4 skm (2.7 smi) of Right Fork Elisha Creek from its headwaters downstream to its confluence with Elisha Creek, 2.3 skm (1.4 smi) of Left Fork Elisha Creek from its headwaters downstream to its confluence with Elisha Creek, and 2.9 skm (1.8 smi) of Elisha Creek from its confluence with Right Fork Elisha Creek downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured throughout Unit 23 (Service unpublished data). A portion of this unit is privately owned (3.0 skm (1.9 smi)), but the majority of the unit is in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 23 is relatively undisturbed and dominated by forest. A few scattered residences are located along Elisha Creek Road at the downstream end of the Elisha Creek valley (near the mouth of Elisha Creek). A few oil and gas wells are scattered throughout the drainage. Elisha Creek is 1 of 11 Red Bird River tributaries (Units 18–28) that support Kentucky arrow populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 23, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, illegal offroad vehicle use, logging (on private land), timber management (on DBNF), inadequate sewage treatment, and natural gas and oil exploration activities. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 24: Gilberts Big Creek, Clay and Leslie Counties, Kentucky. Unit 24 is located east of KY 66 and generally parallel to Gilberts Creek Road in southeastern Clay County and western Leslie County. This unit includes 7.2 skm (4.5 smi) of Gilberts Big Creek from its headwaters downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured throughout this unit. A portion of this unit is privately owned (2.0 skm (1.2 smi)), but the majority of the unit is in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 24 is relatively undisturbed and dominated by forest. A few scattered residences and small farms are located along Gilberts Creek Road at the downstream end of the valley near the mouth of Gilberts Big Creek. Several gas and oil wells are also scattered throughout the valley. Gilberts Big Creek is 1 of 11 Red Bird River tributaries (Units 18–28) that support Kentucky arrow darter populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 24, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, off-road vehicle use, logging (on private land), timber management (on DBNF), inadequate sewage treatment, agricultural runoff, and natural gas and oil exploration activities. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 25: Sugar Creek, Clay and Leslie Counties, Kentucky. Unit 25 is located off Sugar Creek Road in southeastern Clay County and western Leslie County and includes 7.2 skm (4.5 smi) of Sugar Creek from its headwaters downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured throughout this unit (Thomas 2008, p. 4; Thomas et al. 2014, p. 23). A portion of this unit is privately owned (1.1 skm (0.7 smi)), but the majority of the unit is in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1– 14). The watershed surrounding Unit 25 is relatively undisturbed and dominated by forest. A few scattered residences and small farms are located along Sugar Creek Road at the downstream end of the valley near the mouth of Sugar Creek. Several gas and oil wells are also scattered throughout the valley. Sugar Creek is 1 of 11 Red Bird River tributaries (Units 18–28) that support Kentucky arrow darter populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 25, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, off-road vehicle use, logging (on private land), timber management (on DBNF), inadequate sewage treatment, agricultural runoff, and natural gas and oil exploration activities. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 26: Big Double Creek and Tributaries, Clay County, Kentucky. Unit 26 is located adjacent to Big Double Creek Road in southeastern Clay County. This unit includes 1.4 skm (0.9 smi) of Left Fork Big Double Creek from its headwaters downstream to its confluence with Big Double Creek, 1.8 skm (1.1 smi) of Right Fork Big Double Creek from its headwaters downstream to its confluence with Big Double Creek, and 7.1 skm (4.4 smi) of Big Double Creek from its headwaters downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured from numerous localities in Unit 26, which has been surveyed regularly by KDFWR and Service personnel (Thomas 2008, p. 4; Thomas et al. 2014, p. 23; Service unpublished data). This unit is entirely in Federal ownership (administered by DNBF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 26 is relatively undisturbed and dominated by forest, with about 90 percent in Federal ownership (administered by DBNF). The only residential development is concentrated along Arnett Fork Road, which parallels Arnett Fork, a first order tributary of Big Double Creek. A USFS public use area (Big Double Creek Recreational Area) is located adjacent to Unit 26, approximately 1.6 skm (1.0 smi) upstream of Arnett Fork. This area consists of a gravel road and parking lot, a bathroom facility, several picnic tables, and two maintained fields connected by a pedestrian bridge over Big Double Creek. Upstream of the public use area, Big Double Creek can be accessed via USFS Road 1501, which extends upstream to the confluence of the Left and Right Forks. Big Double Creek is 1 of 11 Red Bird River tributaries (Units 18–28) that support Kentucky arrow darter populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 26, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation) associated with road runoff, off-road vehicle use, and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 27: Little Double Creek, Clay County, Kentucky. Unit 27 is located adjacent to Little Double Creek Road in southeastern Clay County. This unit includes 3.4 skm (2.1 smi) of Little Double Creek from its headwaters downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured from two localities in Unit 27 (Thomas 2008, p. 4; Service unpublished data). One hundred percent of this unit is in Federal ownership (administered by DBNF), and the DBNF's Redbird Ranger District headquarters is located off KY 66 at the mouth of Little Double Creek. Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1– 14). The watershed surrounding Unit 27 is entirely forested, with no private residences or other structures. The only interruption in the canopy of the watershed is the Little Double Creek Road corridor, which traverses the length of the valley. Little Double Creek is 1 of 11 Red Bird River tributaries (Units 18–28) that support Kentucky arrow darter populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 27, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation) associated with road runoff, illegal off-road vehicle use, and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 28: Jacks Creek, Clay County, Kentucky. This unit is located along Jacks Creek Road, north of Hal Rogers Parkway and east of KY 66 in eastern Clay County. Unit 28 includes 5.9 skm (3.7 smi) of Jacks Creek from its headwaters downstream to its confluence with the Red Bird River. Live Kentucky arrow darters have been captured from Unit 28 just downstream of the Crib Branch confluence (Service 2012, entire). A small portion of this unit is in Federal ownership (0.5 skm (0.3 smi)), but the majority of the unit is privately owned. For the portion of the unit in Federal ownership (administered by DBNF), land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The valley bottom surrounding Unit 28 is composed of a mixture of residences (many in clusters) and small farms (e.g., pasture, hayfields) scattered along Jacks Creek Road, which parallels Jacks Creek for most of its length. Ridgetops and hillsides in most of the valley are relatively undisturbed and dominated by forest. Jacks Creek is 1 of 11 Red Bird River tributaries (Units 18– 28) that support Kentucky arrow darter populations (Thomas 2008, entire; Service 2012, entire). See the description of Unit 18 for more information regarding the characterization of the streams within this drainage. Within Unit 28, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, inadequate sewage treatment, agricultural runoff, inadequate riparian buffers, construction and maintenance of county roads, illegal off-road vehicle use, logging (on private land), and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 29: Long Fork, Clay County, Kentucky. Unit 29 is located along USFS Road 1633, which is west of KY 149 and the Hal Rogers Parkway in eastern Clay County. Unit 29 includes 2.2 skm (1.4 smi) of Long Fork from its headwaters downstream to its confluence with Hector Branch. Live

Kentucky arrow darters have been captured throughout Unit 29 as a result of a reintroduction effort by KDFWR and Conservation Fisheries, Inc. (CFI) of Knoxville, Tennessee (Thomas et al. 2014, p. 23) (see Available Conservation Measures section of our final listing rule published elsewhere in this Federal Register). One hundred percent of this unit is in Federal ownership (administered by DBNF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1– 14). The watershed surrounding Unit 29 is entirely forested, with no private residences or other structures. The only minor interruption in the canopy of the watershed is the USFS Road 1633 corridor, which parallels Long Fork for part of its length. Habitats in Long Fork are similar to other occupied streams (Units 18–28) in the Red Bird River drainage. See the description of Unit 18 for more information regarding the characterization of the streams within the Red Bird drainage. Within Unit 29, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation) associated with road runoff, illegal off-road vehicle use, and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, comprises a portion of the species' core population within the Red Bird River watershed, and contributes to connectivity of streams within the watershed.

Unit 30: Horse Creek, Clay County, Kentucky. Unit 30 is located adjacent to Reynolds Road and Elijah Feltner Road in southwestern Clay County. It includes 5.0 skm (3.1 smi) of Horse Creek from its headwaters downstream to its confluence with Pigeon Roost Branch. Live Kentucky arrow darters have been captured within this unit approximately 1.9 skm (1.2 smi) downstream of the confluence of Horse Creek and Tuttle Branch (Service unpublished data). A portion of Unit 30 is in Federal ownership (2.0 skm (1.2 smi)), but the majority of the unit is privately owned. For the portion of the basin in Federal ownership (administered by DBNF), land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1– 14). The valley bottom surrounding Unit 30 is composed of a mixture of forest, small farms, and residences. Ridgetops and hillsides in most of the valley are relatively undisturbed and dominated by forest. Within Unit 30, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, agricultural runoff, inadequate sewage treatment, lack of riparian buffers, construction and maintenance of county roads, illegal off-road vehicle use, and logging on private land and timber management on DBNF. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species, and represents the only occupied habitat within the Goose Creek watershed.

Unit 31: Bullskin Creek, Clay and Leslie Counties, Kentucky. Unit 31 is located along KY 1482, east of the town of Oneida, Kentucky, in eastern Clay County and northwestern Leslie County. It includes 21.7 skm (13.5 smi) of Bullskin Creek from its confluence with Old House Branch downstream to its confluence with the South Fork Kentucky River. Live Kentucky arrow darters have been captured from Unit 31 at the confluence of Long Branch and just upstream of the confluence of Barger Branch (Thomas 2008, p. 4; Service 2012, entire). A small portion of this unit is in Federal ownership (0.4 skm (0.2 smi)), but the majority of the unit is privately owned. For the portion of the basin in Federal ownership (administered by DBNF), land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The valley bottom surrounding Unit 31 is composed of a mixture of residences (many in clusters) and small farms (e.g., pasture, hayfields) scattered along KY 1482, which parallels

Bullskin Creek for its entire length. Ridgetops and hillsides in most of the valley are relatively undisturbed and dominated by forest, but a few watersheds show signs of active or recent disturbance. Surface coal mining is currently ongoing in the watersheds of Wiles Branch (Permit #826–0649), Barger Branch (Permit #826–0664), and a few unnamed tributaries of Bullskin Creek (Permit #826–0664). Recent logging activities have occurred in the watershed of Panco Branch. Within Unit 31, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, surface coal mining, inadequate sewage treatment, agricultural runoff, lack of riparian buffers, construction and maintenance of county roads, illegal off-road vehicle use, and logging. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species, and provides opportunity for population growth.

Unit 32: Buffalo Creek and Tributaries, Owsley County, Kentucky. Unit 32 is located north of Oneida, Kentucky, and east of KY 11 in southeastern Owsley County. This unit includes 2.0 skm (1.2 smi) of Cortland Fork from its headwaters downstream to its confluence with Laurel Fork, 6.4 skm (4.0 smi) of Laurel Fork from its headwaters downstream to its confluence with Left Fork Buffalo Creek, 4.6 skm (2.9 smi) of Lucky Fork from its headwaters downstream to its confluence with Left Fork Buffalo Crfeek, 5.1 skm (3.2 smi) of Left Fork Buffalo Creek from its headwaters downstream to its confluence with Buffalo Creek, 17.3 skm (10.8 smi) of Right Fork Buffalo Creek from its headwaters downstream to its confluence with Buffalo Creek, and 2.7 skm (1.7 smi) of Buffalo Creek from its confluence with Left Fork Buffalo Creek, and Right Fork Buffalo Creek downstream to its confluence with the South Fork Kentucky River. Live Kentucky arrow darters have been captured from multiple locations throughout Unit 32 (Thomas 2008, p. 4; Service 2012, entire). A portion of this unit is in Federal ownership (administered by DBNF) (14.9 skm (9.3 smi)), but the majority of the unit is in private ownership. For the portion in Federal ownership, land and resource management decisions and activities are guided by DBNF's LRMP (USFS 2004, pp. 1–14). Ridgetops and hillsides in most of the valley surrounding Unit 32 are relatively undisturbed and dominated by forest, but portions of the valley bottom surrounding Unit 32 have been cleared and consist of a mixture of residences (many in clusters) and small farms (e.g., pasture, hayfields, row crops) scattered along roadways. Surface coal mining has been conducted recently or is currently ongoing in the headwaters of Left Fork Buffalo Creek, specifically Stamper Branch of Lucky Fork (Permit #895–0175), Cortland Fork of Laurel Fork (Permit #813–0271), and Joyce Fork of Laurel Fork (Permit #895– 0175). Within Unit 32, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, surface coal mining, inadequate sewage treatment, inadequate riparian buffers, agricultural runoff, construction and maintenance of roads, illegal off-road vehicle use, logging (on private land), and timber management (on DBNF). These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, represents a stronghold for the species within the lower half of the South Fork Kentucky River sub-basin, and likely acts as a source population.

Unit 33: Lower Buffalo Creek, Lee and Owsley Counties, Kentucky. Unit 33 is located along KY 1411 and Straight Fork-Zeke Branch Road in southern Lee and northern Owsley Counties. This unit includes 2.2 skm (1.4 smi) of Straight Fork from its headwaters downstream to its confluence with Lower Buffalo Creek and 5.1 skm (3.2 smi) of Lower Buffalo Creek from its confluence with Straight Fork downstream to its confluence with the South Fork Kentucky River. Live Kentucky arrow darters have been captured within Unit 33 at the confluence of Lower Buffalo Creek and Straight Fork (Thomas 2008, p. 4). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. Ridgetops and hillsides in most of the valley surrounding Unit 33 are relatively undisturbed and dominated by forest, but large portions of the valley bottom surrounding Unit 33 have been cleared and consist of a mixture of residences (many in clusters) and small farms (e.g., pasture, hayfields, row crops). Extensive logging has occurred recently (within the last 7 years) within Jerushia Branch, a first-order tributary of Lower Buffalo Creek. Within this unit, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, construction and maintenance of roads, inadequate sewage treatment, inadequate riparian buffers, agricultural runoff, illegal off-road vehicle use, and logging. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species, and provides opportunity for population growth.

Unit 34: Silver Creek, Lee County, Kentucky Unit 34 is located along along Silver Creek Road, partially within the city limits of Beattyville in central Lee County. This unit includes 6.2 skm (3.9 smi) of Silver Creek from its headwaters downstream to its confluence with the Kentucky River. Live Kentucky arrow darters have been captured within Unit 34 approximately 1.4 skm (0.9 smi) upstream of the mouth of Silver Creek (Thomas 2008, p. 5). This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. The valley surrounding Unit 34 is unusual among occupied watersheds because it is not located in a rural area. The mouth of Silver Creek (downstream terminus of Unit 34) is located within the city limits of Beattyville, and the downstream half of the watershed is moderately developed, with numerous residences along Silver Creek Road. The upstream half of the watershed is less developed and dominated by forest. Within this unit, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, construction and maintenance of roads, inadequate sewage treatment, inadequate riparian buffers, and illegal off-road vehicle use. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, helps to maintain the geographical range of the species, and provides opportunity for population growth.

Unit 35: Travis Creek, Jackson County, Kentucky. Unit 35 is located along Travis Creek Road in eastern Jackson County. This unit includes 4.1 skm (2.5 smi) of Travis Creek from its headwaters downstream to its confluence with Hector Branch. Live Kentucky arrow darters have been captured within Unit 35 approximately 1.8 skm (1.1 smi) upstream of the mouth of Travis Creek. This unit is located almost entirely on private land, except for any small amount that is publicly owned in the form of bridge crossings and road easements. A few agricultural fields are located near the mouth of Travis Creek, but most of the watershed surrounding Unit 35 is forested, with no private residences or other structures. Some of the forest is early successional due to recent logging in the watershed. Within Unit 35, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, off-road vehicle use, inadequate riparian buffers, construction and maintenance of county roads, agricultural runoff, and logging. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, increases population redundancy within the species' range, and provides the opportunity for population growth at the western extent of the species' range.

Unit 36: Wild Dog Creek, Jackson and Owsley Counties, Kentucky. Unit 36 is located west of Sturgeon Creek in eastern Jackson and northwestern Owsley Counties. This unit includes 8.1 skm (5.1 smi) of Wild Dog Creek from its headwaters downstream to its confluence with Sturgeon Creek. Live Kentucky arrow darters have been captured within Unit 36 just upstream of the mouth of Wild Dog Creek. A portion of this unit is in Federal ownership (3.8 skm (2.4 smi)), but the majority of the unit is in private ownership. For the portion of the unit in Federal ownership (administered by DBNF), land and resource management decisions and activities are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 36 is relatively undisturbed and dominated by forest, but a few scattered residences and small farms occur in the headwaters just east of KY 587. Within Unit 36, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, construction and maintenance of roads, illegal off-road vehicle use, inadequate riparian buffers, agricultural runoff, logging (on private land), timber management (on DBNF), and inadequate sewage treatment. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, increases population redundancy within the species' range, and provides the opportunity for population growth at the western extent of the species' range.

Unit 37: Granny Dismal Creek, Lee and Owsley Counties, Kentucky. Unit 37 is located west of Sturgeon Creek in western Lee and eastern Owsley Counties. This unit includes 6.9 skm (4.3 smi) of Granny Dismal Creek from its confluence with Harris Branch downstream to its confluence with Sturgeon Creek. Live Kentucky arrow darters have been captured within Unit 37 approximately 1.1 skm (0.7 smi) upstream of the mouth of Granny Dismal Creek. A portion (2.5 skm (1.6 smi)) of this unit is in Federal ownership (administered by DBNF), but the majority of the unit is privately owned. Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 37 is relatively undisturbed and dominated by forest, but a few scattered residences and small farms occur in the headwaters just east of KY 587. Within Unit 37, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, construction and maintenance of roads, illegal off-road vehicle use, inadequate riparian buffers, agricultural runoff, logging (on private land), timber management (on DBNF), and inadequate sewage treatment. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, increases population redundancy within the species' range, and provides the opportunity for population growth at the western extent of the species' range.

Unit 38: Rockbridge Fork, Wolfe County, Kentucky. Unit 38 is located within the Red River Gorge region in northwestern Wolfe County and represents the only occupied habitat within the Red River drainage. This unit includes 4.5 skm (2.8 smi) of Rockbridge Fork from its confluence with Harris Branch downstream to its confluence with Sturgeon Creek. Live Kentucky arrow darters have been captured within Unit 38 approximately 0.2 skm (0.1 smi) upstream of the mouth of Rockbridge Fork. This unit is entirely in Federal ownership (administered by DBNF). Land and resource management decisions and activities within the DBNF are guided by DBNF's LRMP (USFS 2004, pp. 1–14). The watershed surrounding Unit 38 is relatively undisturbed and dominated by forest, but a few scattered residences and small farms occur in the headwaters of Rockbridge Fork near the Mountain Parkway (KY 402). Within Unit 38, the physical and biological features may require special management considerations or protection to address adverse effects (e.g., siltation, water pollution) associated with road runoff, illegal offroad vehicle use, agricultural runoff, timber management (on DBNF), and inadequate sewage treatment. These threats are in addition to random effects of drought, floods, or other natural phenomena. This unit provides habitat for reproduction and feeding, increases population redundancy within the species' range, and provides the opportunity for population growth at the western extent of the species' range.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the primary constituent elements of the physical or biological features essential to the conservation of the Kentucky arrow darter consist of five components:

(i) Primary Constituent Element 1— Riffle-pool complexes and transitional areas (glides and runs) of geomorphically stable, first- to thirdorder streams of the upper Kentucky River drainage with connectivity between spawning, foraging, and resting sites to promote gene flow throughout the species' range.

(ii) Primary Constituent Element 2— Stable bottom substrates composed of gravel, cobble, boulders, bedrock ledges, and woody debris piles with low levels of siltation.

(iii) Primary Constituent Element 3— An instream flow regime (magnitude, frequency, duration, and seasonality of discharge over time) sufficient to provide permanent surface flows, as measured during years with average rainfall, and to maintain benthic habitats utilized by the species.

(iv) Primary Constituent Element 4— Adequate water quality characterized by seasonally moderate stream temperatures (generally = 24 °C or 75 °F), high dissolved oxygen concentrations (generally = 6.0 mg/L), moderate pH (generally 6.0 to 8.5), low stream conductivity (species' abundance decreases sharply as conductivities exceed 261 mS/cm and species is typically absent above 350 mS)/cm, and low levels of pollutants. Adequate water quality is the quality necessary for normal behavior, growth, and viability of all life stages of the Kentucky arrow darter.

(v) Primary Constituent Element 5—A prey base of aquatic macroinvertebrates, including mayfly nymphs, midge larvae, blackfly larvae, caddisfly larvae, stonefly nymphs, and small crayfishes.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on November 4, 2016.

Activities in or adjacent to these areas of critical habitat may affect one or more of the physical or biological features essential to the Kentucky arrow darter. For example, features in these critical habitat units may require special management due to threats associated with resource extraction (coal surface mining, logging, natural gas and oil exploration), agricultural runoff (livestock, row crops), lack of adequate riparian buffers, construction and maintenance of State and county roads, land development, off-road vehicle use, and other nonpoint-source pollution. These threats are in addition to adverse effects of drought, floods, or other natural phenomena. Other activities that may affect physical and biological features in the critical habitat units include those listed in the Effects of Critical Habitat Designation section, below. Management activities that could ameliorate these threats include, but are not limited to, the use of best management practices (BMPs) designed to reduce sedimentation, erosion, and stream bank destruction; development of alternatives that avoid and minimize stream bed disturbances; an increase of stormwater management and reduction of stormwater flows into stream systems; preservation of headwater springs and streams; regulation of offroad vehicle use; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water.

Life History

Feeding Narrative

Adult: Lotrich (1973, p. 381) reported that Kentucky arrow darters captured in 1967 and 1968 from Clemons Fork fed primarily on mayflies, specifically the families Heptageniidae (genus Stenonema) and Baetidae. Mayflies comprised 77 percent of identifiable food items (420 of 542 items) in 57 arrow darter stomachs. Large arrow darters (individuals over 70 mm [2.8 in] TL) appeared to specialize on small crayfish, as 7 of 8 stomachs contained crayfish ranging in size from 11 to 24 mm (0.4 to 0.9 in). Lotrich (1973, p. 381) considered this to be noteworthy since stomachs of small arrow darters (less than 70 mm [2.8 in]) and stomachs of other darter species did not contain crayfish. He suggested that larger arrow darters were utilizing a different energy source, thus removing themselves from direct competition for food with other fishes in first and second order streams. This would allow these larger individuals to exploit an abundant food source and survive in extreme headwater habitats. Other arrow darter food items reported by Lotrich (1973, p. 381) and Etnier and Starnes (1993, p. 523) included larval blackflies (family Simuliidae) and midges (Chironomidae), with lesser amounts of caddisfly larvae, stonefly nymphs, and beetle larvae. Etnier and Starnes (1993, p. 523) reported that juvenile arrow darters feed on microcrustaceans and dipteran larvae. Young arrow darters can reach 50 mm TL by the end of the first year (Lotrich 1973, p. 384-385; Lowe 1979). Lotrich (1973, p. 384) indicated mean length at age 2 of about 65 mm (2.6 in) and was unable to differentiate between older age classes (age 3+). Lowe (1979) reported four age classes, but growth was variable after age 1. (USFWS, 2013)

Reproduction Narrative

Adult: Male darters establish territories over riffles from March to May, where they are quite conspicuous in water 5 to 15 cm (2 to 6 in) deep (Kuehne and Barbour 1983, p. 71). During spawning (April to June), the species utilizes riffle habitats with moderate flow (Kuehne and Barbour 1983, p. 71). Males fan out a depression in the substrate and defend these sites vigorously. Initial courtship behavior involves rapid dashes, fin-flaring, nudging, and quivering motions by the male followed by similar quivering responses of the female, who then precedes the male to the nest. The female partially buries herself in the substrate, is mounted by the male, and spawning occurs (Etnier and Starnes 1993, p. 523). It is assumed that the male continues to defend the nest until the eggs have hatched. Bailey (1948) described collected females as bulging with eggs in April, probably the peak spawning period. Lowe (1979) studied the biology of E. sagitta and determined that the peak spawning period was during April when water temperatures reached 13 degrees C (55 degrees F). One-year olds are generally sexually mature and participate in spawning with older age classes (Etnier and Starnes 1993, p. 523). Females produce between 200 and 600 eggs per season, with tremendous variation resulting from size, age, condition of females, and stream temperature (Rakes 2014, pers. comm.). (USFWS, 2013)

Geographic or Habitat Restraints or Barriers

Adult: Impoundments (USFWS, 2013)

Environmental Specificity

Adult: Generalist (USFWS, 2013)

Tolerance Ranges/Thresholds

Adult: Sensitive to water quality degradation (USFWS, 2013)

Site Fidelity

Adult: Unknown

Dependency on Other Individuals or Species for Habitat

Adult: Not applicable

Habitat Narrative

Adult: During the most recent range-wide surveys (Thomas 2008, p. 6; USFWS 2010, pp. 1-13), Kentucky arrow darters were found in pools or transitional areas between riffles and pools (runs and glides) in moderate-to high-gradient streams. Individuals were usually associated with bedrock, boulder, and cobble substrates and occasionally observed around woody debris. Stream widths ranged from 1.5 to 20 meters (m) (5 to 66 feet [ft]), and depths at which individuals were captured ranged from 10 to 45 centimeters (cm) (4 to 18 in). During 2007 and 2008, Thomas (2008, p. 6) observed Kentucky arrow darters in streams ranging in size from first to third order, with 60 percent occurring in second order streams. The majority (72 percent) of these streams were in watersheds draining an area of 20 square kilometers (km2) (7.7 square miles [mi2]) or less.Many of these habitats, especially those in first order reaches, can be intermittent in nature. Lotrich (1973, p. 394) observed riffle habitats in Clemons Fork (Breathitt County) that were completely dry by late summer. These habitats continued to support arrow darters, but fishes were crowded into isolated pools once drying occurred. (USFWS, 2013)

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Dispersal

Adult: Moderately low

Immigration/Emigration

Adult: Not likely because of disconnected suitable habitat

Dependency on Other Individuals or Species for Dispersal

Adult: Not applicable

Dispersal/Migration Narrative

Adult: Recorded movements ranged from 134 m (439 ft) (upstream movement) to 4,078 m (13,379 ft or 2.5 mi) (downstream movement by a female in Elisha Creek). There is not a lot of information regarding the dispersal of this species. (USFWS, 2016)

Population Information and Trends

Population Trends:

Declining (USFWS, 2013)

Species Trends:

Declining (USFWS, 2013)

Population Growth Rate:

Unknown

Number of Populations:

52 streams; 6 sub-basins (USFWS, 2022)

Population Size:

unknown

Minimum Viable Population Size:

unknown

Resistance to Disease:

unknown

Adaptability:

Low

Population Narrative:

Population estimates for the Kentucky arrow darter are not available; however, recent survey data (Thomas 2008, pp. 3-6; USFWS 2009, pp. 1-4) revealed that sites with arrow darters had an average of only three individuals per 100-m (328-ft) sampling reach and a median of two individuals per reach (range of 1 to 10 individuals). Recent surveys by the USFS (Brandt, pers. comm., 2011) from Laurel Fork and Cortland Branch of Left Fork Buffalo Creek (South Fork Kentucky River basin) produced slightly higher capture rates (an average of 5 darters per 100-m (328-ft) sampling reach). The low abundance values (compared to other darters) are not surprising since both arrow darter species generally are not observed in large numbers, even in those streams where disturbance has been minimal (M. Thomas, pers. comm., 2010). The largest populations of Kentucky arrow darters were located in the following streams/basins: Several tributaries of South Fork Kentucky River, Redbird District of DBNF (Clay and Leslie Counties); Hell Creek, Walker Creek, and Frozen Creek - direct tributaries of North Fork Kentucky River (Breathitt and Lee Counties); Clemons Fork and Coles Fork of Buckhorn Creek, North Fork Kentucky River basin (Breathitt County). (USFWS, 2013). Extant populations of the Kentucky arrow darter currently occupy 52 small stream systems (88 HUC14 watersheds) (Figure 1; Appendix A). Populations in ten of these streams have been discovered since 2000, and one additional population (Long Fork, Clay County) was established through a reintroduction project led by KDFWR and Conservation Fisheries, Inc. (Thomas and Brandt 2020). Of the species' 52 extant streams, we consider over half of these populations (27) to be "vulnerable", and most remaining populations are isolated and restricted to short stream reaches (Appendix A). No extirpations have been documented since the species was listed in 2016 (USFWS, 2022).

Threats and Stressors

Stressor: Coal Mining
Exposure:
Response:
Consequence:
Narrative: Coal mining activities represent the most imminent and substantial source of threats to the subspecies because these activities have the potential to significantly, and often permanently, alter instream water quality and cause physical habitat disturbance. Numerous studies have documented the fact that streams receiving discharge from mined areas exhibit characteristics not observed in unmined watersheds: (1) altered water quality conditions (Curtis 1973, pp. 153-155; Dyer and Curtis 1977, pp. 10-13; Dyer 1982, pp. 1-16; Hren et al. 1984, pp. 5-34; US EPA 2003, pp. 77-84; Pond et al. 2008, pp. 721-723); (2) increased sediment loads (Branson and Batch 1972, p. 513; Parker and Carey 1980, pp. 33-49 ; Osterkamp et al. 1984, pp. 59, 63; Pond 2004, pp. 19-20); (3) increased hydrologic response time to storm events (Bryan and Hewlett 1981, p. 298); (4) altered flow duration curves (USGS 2001, pp. 16-17); and (5) altered or changed channel morphology. As of March 2010, over 465 mining permits were active in the upper Kentucky River basin (LaSage, pers. comm., 2010). Some of these permits were active and coal removal was still occurring (about 360 permits), while others were inactive with reclamation activities underway (about 106 permits). Impacts to instream water quality (chemistry) occur through inputs of dissolved metals and other solids that elevate stream conductivity, increase sulfate levels, and/or increase stream pH, (Curtis 1973, pp. 153-155; Pond 2004, pp. 6-7, 38-41; Hartman et al. 2005, p. 95; Mattingly et al. 2005, p. 59; Palmer et al. 2010, pp. 148-149). As rock strata and overburden (excess material) are exposed to the atmosphere, precipitation leaches metals and other solids (e.g., Calcium, Magnesium, Sulfates, Iron, Manganese) from these materials and carries them in solution to receiving streams (Pond 2004, p 7). If valley fills are used as part of the mining activity, precipitation and groundwater percolate through the fill and dissolve minerals until they discharge at the toe of the fill as surface water (Pond et al. 2008, p. 718). Both of these scenarios result in elevated conductivity, sulfates, and hardness in the receiving stream. Increased levels of these metals and other dissolved solids have been shown to exclude fish species from streams in eastern Kentucky, including the federally threatened blackside dace (Chrosomus cumberlandensis) in the upper Cumberland River basin (Mattingly et al. 2005, pp. 59-62). Based on earlier research by Branson and Batch (1974, pp. 81-83) and Dyer and Curtis (1977, pp. 1-13) and recent fish survey results by Thomas (2008, pp. 3-6) and USFWS (2009, pp. 1-4), it is clear that degraded water quality conditions in the upper Kentucky River basin have adversely affected Kentucky arrow darter populations. From late 1967 to 1975, Branson and Batch (1972, pp. 507-518; 1974, pp. 81-83), and Dyer and Curtis (1977, pp. 1-13) studied the effects of strip mining activities on water quality and stream fishes in the Quicksand Creek (Leatherwood Creek) and Buckhorn Creek (Bear Branch) basins, Breathitt County. Six first-order watersheds, three in the Leatherwood Creek basin and three in the Bear Branch basin, were investigated during the study, beginning in late summer 1967 prior to the onset of mining and continuing until 1975. One of the six small watersheds, Jenny Fork, was not mined and

served as a control watershed. Water quality data from mined watersheds showed increases in conductivity, sulfate, magnesium, bicarbonate, and silt deposition (Dyer and Curtis 1977, pp. 3-7, 13). Water quality data from the reference site, Jenny Branch, showed little variation and remained at baseline levels. Fish community data from the Bear Branch and Leatherwood Creek watersheds showed that fishes were pushed downstream or eliminated from the fauna altogether in mined watersheds (Branson and Batch 1972, pp. 514-515; Branson and Batch 1974, pp. 82-83). The only exception to this was the creek chub, which appeared to be tolerant of mining impacts. Several species, silver shiner (Notropis photogenis), Kentucky arrow darter, Johnny darter, variegate darter (Etheostoma variatum), greenside darter (E. blenniodes), and emerald darter were eliminated from Leatherwood Creek. Two species, northern hogsucker (Hypentelium nigricans) and blackside darter (Percina maculata), were eliminated from both streams. During the last fish sampling event in September 1972, Kentucky arrow darters were observed at the mouth of Bear Branch (Branson and Batch 1974, p. 82), but instream conductivity levels had not peaked. Branson and Batch (1972, p. 514) also did not observe young darters and minnows during later visits (early 1970s), suggesting that reproduction had been curtailed by the mining activity. Thomas (2008, p. 5) and USFWS (2009, pp. 1-4) resurveyed these streams in 2008 and found that conductivity levels had increased since the 1970s, reaching 845 µS in Bear Branch and 1008 µS in Leatherwood Creek. Kentucky arrow darters were not observed at these sites. Recent range-wide surveys by Thomas (2008, pp. 3-6) and USFWS (2009, pp. 1-4) demonstrated that Kentucky arrow darters are excluded from watersheds when conductivity levels exceed about 250 µS. Mattingly et al. (2005, pp. 59-62) reported virtually identical results for the federally threatened blackside dace in the upper Cumberland River basin. Historic arrow darter sites that lacked darters had higher conductivity values (average = 680 µS) than historic sites that continued to support arrow darters (average = 105 µS). Arrow darters were observed at only one historic site (USFWS 2009, pp. 1-4), Walker Creek (Owsley County), with a conductivity value greater than 250 µS (400 µS). There is a pattern of increasing conductivity and loss of arrow darter populations which is evident in the fish and water quality data from the Buckhorn Creek basin (1962 to present) in Breathitt and Knott Counties. Kentucky arrow darters and other fish species were first reported from the basin in 1962 by Kuehne (1962, p. 608-609), who surveyed sites on the Buckhorn Creek mainstem and numerous tributaries - Bear Branch, Clemons Fork, Coles Fork, Laurel Fork, Lewis Fork, and Long Fork. Kuehne (1962, p. 608-609) documented Kentucky arrow darters at 16 of 22 sites within the basin. Since that time, the majority of these watersheds have been mined extensively and conductivities have increased, especially in areas to the south and east of the Buckhorn Creek mainstem. The only exceptions are two unmined watersheds on UKs Robinson Forest (Clemons Fork and Coles Fork) and an approximate 450-m (1,500-ft) reach in the headwaters of Buckhorn Creek. Thomas (2008, p. 5) and USFWS (2009, pp. 1-4; 2010, pp. 1-13) resurveyed sites on all historic streams (and most historic sites) in the Buckhorn Creek basin from 2007 to 2010, observing Kentucky arrow darters in only Clemons Fork, Coles Fork, and Buckhorn Creek, upstream of Emory Branch. Conductivity levels of Clemons Fork, Coles Fork, and Buckhorn Creek (upstream of Emory Branch) remained at or near background levels, (50 to 110 µS), but conductivity levels at other streams were elevated, with some of these being exceptionally high. Portions of two of these streams, Buckhorn Creek (mile 0-6.8) and Long Fork (mile 0-8.95) have been placed on Kentuckys 303d list of impaired waters (KDOW 2008, pp. 65-101). Mine drainage also causes physical and chemical impacts to streams as a result of the precipitation of entrained metals and sulfate, which become unstable in solution (USEPA 2003, pp. 77-84; Pond 2004, p. 7). Hydroxide precipitants are formed from iron and aluminum, creating orange or white sludge (yellow boy) that forms a thick coating on stream substrates (Pond 2004, p. 7). Most affected streams also have elevated levels of calcium in solution, and if pH is elevated, calcium sulfate ($CaSO_4$) or calcium carbonate ($CaCO_3$) will precipitate (USEPA 2003, pp. 77-84; Pond 2004, p. 7). These precipitants accumulate on substrates, encrusting and cementing stream sediments, making them unsuitable for colonization by invertebrates and rendering them unsuitable as foraging or spawning habitat for the Kentuc

Stressor: Silviculture
Exposure:
Response:
Consequence:
Narrative: Logging activities can adversely affect Kentucky arrow darters through sedimentation of instream habitats, removal of streamside (riparian) vegetation, and direct channel disturbance. Sedimentation occurs as soils are disturbed, the overlying leaf or litter layer is removed, and sediment is carried overland from logging roads, stream crossings, skid trails, and riparian zones during storm events. Excess sediment can bury instream habitats used by the species for foraging, reproduction, and sheltering, and it can disrupt the dynamic equilibrium of channel width, depth, flow velocity, discharge, channel slope, roughness, sediment load, and sediment size that maintains stable channel morphology. This can lead to channel instability and further degradation of instream habitats. Reductions in riparian vegetation can adversely affect the species through increased solar radiation, elevated stream temperatures, loss of allochthonous (organic material originating from outside the channel) food material, and bank instability / erosion. Direct channel disturbance occurs primarily at stream crossings during culvert, log, or rock placement. Severe impacts can occur when loggers use stream channels illegally as skid trails (M. Floyd, pers. obs. 2009).

Stressor: Sediment (Nonpoint-Source)
Exposure:
Response:
Consequence:
Narrative: Sediment (siltation) has been listed repeatedly by the Kentucky Natural Resources and Environmental Protection Cabinet (Division of Water) as the most common stressor of aquatic communities in the upper Kentucky River basin (KDOW 2008, pp. 65-101). Sedimentation comes from a variety of sources, but KDOW identified the primary sources of sediment as loss of riparian habitat, surface coal mining, and legacy coal extraction (KDOW 2008, pp. 65-101). All of these activities can result in canopy removal, channel disturbance, and increased siltation, thereby degrading habitats used by fishes for both feeding and reproduction. The reduction or loss of riparian vegetation results in the elevation of stream temperatures, destabilization of stream banks and siltation, and removal of submerged root systems that provide habitat for fish and acroinvertebrates (Mattingly et al. 2005, p. 5). Unpaved (dirt, gravel) roads represent another sediment source that can deliver large amounts of silt or sand during storm events. Many of these roads are poorly ditched, which creates eroded channels within the roadway that can carry sediment directly to nearby streams. Numerous streams within the Kentucky arrow darters current range have been identified as impaired (primarily due to siltation from mining, logging, agricultural activities, and land development) and have been included on Kentuckys 303(d) list of impaired waters (KDOW 2008, pp. 65-101). Sediment has been shown to damage and suffocate fish gills and eggs, larval fishes, bottom dwelling algae, and other organisms; reduce aquatic insect diversity and abundance; and, ultimately, negatively impact fish growth, survival, and reproduction (Waters 1995, pp. 5-7; Meyer and Sutherland (2005, pp. 2-3). Wood

and Armitage (1997, pp. 211-212) identified at least five impacts of sedimentation on fish, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency. Kentucky arrow darter habitats are also affected when riparian corridors are disturbed or significantly altered during mine preparation, logging activities, or road construction.

Stressor: Oil and Gas
Exposure:
Response:
Consequence:
Narrative: Oil and gas exploration activities represent a threat to the species. Exploration and drilling activities typically involve the construction of new roads and stream crossings, so the potential is high for sedimentation and other direct, physical disturbance to stream channels (e.g., culvert placement, road building). Water quality degradation is a more significant threat associated with these activities because releases of chemicals can occur during the drilling process. Significant releases from gas well sites have been documented within the upper Cumberland River basin (M. Floyd, pers. obs., 2009) and likely occur in the Kentucky River basin as well. Walker Creek, a direct tributary of the North Fork Kentucky River, is the only stream within the subspecies range that continues to support arrow darters despite having a conductivity value (400 µS) greater than 250 µS. At the time of the field survey, the source of the elevated conductivity was unknown, but subsequent review of oil and gas mapping revealed that legacy oil and gas wells were abundant in the watershed, and along with legacy mining impacts, likely have contributed to the elevated conductivity. An adjacent stream, Hell Creek, has been placed on Kentuckys 303d list due to impacts from abandoned mines and petroleum/gas production activities.

Stressor: Non-point source pollutants
Exposure:
Response:
Consequence:
Narrative: Other nonpoint-source pollutants that affect the Kentucky arrow darter include domestic sewage (through septic tank leakage or straight pipe discharges) and agricultural pollutants such as animal waste, fertilizers, pesticides, and herbicides. Nonpoint-source pollutants can cause excess nutrification (increased levels of nitrogen and phosphorus) (Table 3, Laurel Creek), excessive algal growth, instream oxygen deficiencies, and other changes in water chemistry that can seriously impact aquatic species (KDOW 1996, pp. 48-50; KDOW 2006, pp. 70-73).

Stressor: Small, fragmented populations
Exposure:
Response:
Consequence:
Narrative: The disjunct nature of some Kentucky arrow darter populations prohibits the natural interchange of genetic material between populations, and the small population size reduces the reservoir of genetic diversity within populations. This can lead to inbreeding depression and reduced fitness of individuals (Soule 1980, pp. 157-158; Hunter 2002, pp. 97-101). It is possible

that some of the arrow darter populations are below the effective population size required to maintain long-term genetic and population viability (Soule 1980, p. 162-164; Hunter 2002, pp. 105-107).

Stressor: Climate change
Exposure:
Response:
Consequence:
Narrative: Climate change has the potential to increase the vulnerability of the Kentucky arrow darter to random detrimental events (e.g., McLaughlin et al. 2002; Thomas et al. 2004). Global warming is expected to result in increasing frequency and duration of droughts and the strength of storms (e.g., Cook et al. 2004). Severe droughts similar to those that affected eastern Kentucky in 2007 and 2008 could be intensified by rising mean air temperatures and reduced precipitation amounts as predicted by Mauer et al. (2007) and ClimateWizard (2009) over the next 40 years in eastern Kentucky.

Stressor: Invasion of Hemlock Wooly Adelgid
Exposure:
Response:
Consequence:
Narrative: The hemlock woolly adelgid (Adelges tsugae), an aphid-like insect native to Asia, represents a potential threat to the Kentucky arrow darter because it has the potential to severely damage stands of eastern hemlocks (Tsuga canadensis) that occur within the species' range. Loss of hemlocks along Kentucky arrow darter streams has the potential to result in increased solar exposure and subsequent elevated stream temperatures, bank erosion, and excessive inputs of woody debris that will clog streams and cause channel instability and erosion (Townsend and Rieske-Kinney 2009, pp. 1–3). (USFWS, 2016)

Stressor: Sewage bacteria
Exposure:
Response:
Consequence:
Narrative: the occurrence of sewage-bacteria (Sphaerotilus) may a pose a threat with respect to fish condition and health (Pond 2015, pers. comm.). These bacteria are prevalent in many eastern Kentucky streams where straight-pipe sewage discharges exist and can often affect other freshwater organisms. The presence of these bacteria could also indicate the presence of other pathogens. Gill and body parasites such as flukes (flatworms) and nematodes (roundworms) have been noted in other species of Etheostoma (Page and Mayden 1981, p. 8), but it is unknown if these parasites infest or harm the Kentucky arrow darter. (USFWS, 2016)

Stressor: Restricted range and population size
Exposure:
Response:
Consequence:
Narrative: The disjunct nature of some Kentucky arrow darter populations (figures 2 and 3, above) likely restricts the natural exchange of genetic material between populations and could make natural repopulation following localized extirpations of the species unlikely without human intervention. Populations can be further isolated by anthropogenic barriers, such as dams,

perched culverts, and fords, which can limit natural dispersal and restrict or eliminate connectivity among populations (Eisenhour and Floyd 2013, pp. 82–83). Such dispersal barriers can prevent reestablishment of Kentucky arrow populations in reaches where they suffer localized extinctions due to natural or human-caused events. The localized nature and small size of many populations also likely makes them vulnerable to extirpation from intentional or accidental toxic chemical spills, habitat modification, progressive degradation from runoff (nonpoint- source pollutants), natural catastrophic changes to their habitat (e.g., flood, scour, drought), and other stochastic disturbances (Soule 1980, pp. 157-158; Hunter 2002, pp. 97-101; Allendorf and Luikart 2007, pp. 117-146). Inbreeding and loss of neutral genetic variation associated with small population size can further reduce the fitness of the population (Reed and Frankham 2003, pp. 230–237), subsequently accelerating population decline (Fagan and Holmes 2006, pp. 51–60). (USFWS, 2016)

Recovery

Reclassification Criteria:
Recovery Priority Number: 11 (USFWS, 2022)

Delisting Criteria:
Not applicable

Recovery Actions:

- Conservation measures for the Kentucky arrow darter should be concentrated in those watersheds where populations still occur and should be focused primarily on the protection and restoration of the existing water and habitat quality of these systems. Seven conservation actions were developed for the subspecies habitat guild as part of KDFWRs State Wildlife Action Plan (KDFWR 2005, p. 2.2.2): (1) the creation of financial incentives to protect riparian corridors and watersheds, (2) acquisition and conservation easements of critical aquatic habitat, (3) encouragement and assistance in developing and implementing best management practices, (4) restoration of degraded habitats, (5) coordination and implementation of existing Farm Bill programs or other federal incentive programs, (6) education of user groups on significance and importance of riparian corridors and watersheds, and (7) development and initiation of local watershed improvement projects. Other appropriate conservation actions identified in KDFWRs plan include the development of protection and enhancement (mitigation) plans for mined watersheds and the development of strategies for reintroduction and enhancement of populations. In order to achieve conservation goals, the Service could pursue the development of candidate conservation agreements and candidate conservation agreements with assurances with potential partners. Conservation efforts could be augmented through additional research on the species current distribution, life history, environmental requirements, and movement patterns.
- Propagation/Reintroduction Effort Clay and Leslie Counties, DBNF: KDFWR identified the Kentucky arrow darter as a Species of Greatest Conservation Need (SGCN) in its State Wildlife Action Plan (KDFWR 2005, p. 2.2.2). The plan identifies conservation issues (threats), conservation actions, and monitoring strategies for 251 animal species belonging to one of 20 terrestrial and aquatic habitat guilds (collection of species that occur in the same habitat). To fully understand these conservation issues, the KDFWR developed a priority list of research and survey needs for Kentuckys SGCN. The KDFWR attempted to

address two of these needs in 2008 by initiating a propagation and reintroduction study for the Kentucky arrow darter through the Services State Wildlife Grant program (Ruble et al. 2010, pp. 1-8). The study was designed to document details on the subspecies reproductive biology and to begin conservation actions (e.g., propagation and augmentation) that would preclude the need to list the Kentucky arrow darter as threatened or endangered under the ESA. The KDFWR partnered with Conservation Fisheries, Inc. (CFI) to develop successful spawning protocols and produce the offspring needed to augment populations within the subspecies current range.

- Candidate Conservation Agreement (CCA) with DBNF: The KFO and the DBNF are working cooperatively to develop a candidate conservation agreement for the Kentucky arrow darter on the DBNF. Over half of the species extant streams occur on lands owned and managed by the DBNF, so conservation of these populations is essential to the species recovery, and a DBNF-specific conservation plan is needed to guide those efforts. The DBNF and KFO met in January 2013 to discuss potential conservation actions, including (1) an evaluation of relevant Forest Plan standards to identify any impediments to KAD conservation and ways to address those impediments, (2) a review of available data that would help identify any immediate opportunities for conservation success with the KAD, (3) the development of a watershed-based threat matrix for USFS lands and watersheds, (4) identifying and ranking potential stream restoration opportunities, (5) evaluating the implications of rainbow trout stocking within USFS lands and watersheds, and (6) the development of a Candidate Conservation Agreement for the DBNF. Both agencies are currently working on action items, and completion of a draft CCA is scheduled for July 2013.
- Range-wide Candidate Conservation Agreement with Assurances (CCAA). The KFO is assisting the KDFWR in development of a range-wide CCAA for the species: To date, the process has included a Science Advisory Committee (SAC) meeting in January 2013 and a Stakeholder meeting in February 2013. The SAC meeting was moderated by KDFWR and included a total of 18 biologists, representing a variety of agencies/groups: Appalachian Wildlife Foundation, Appalachian Technical Services, Austin Peay State University, Conservation Fisheries Inc., DBNF, KDFWR, Kentucky Division of Water, KSNPC, Morehead State University, The Nature Conservancy, U. S. Environmental Protection Agency, USFWS (KFO), and the U. S. Geological Survey. The SAC reviewed and discussed the species biology and current status/threats and identified three general research needs or priorities for the species: (1) genetics, (2) stressor identification, and (3) dispersal behavior (movement).
- Upper Kentucky River Basin Distributional Study and Habitat Characterization: The KFO is working cooperatively with the KSNPC to investigate the distribution, status, population size, and environmental resource use of the Kentucky arrow darter within the upper Kentucky River system. One important aspect in assessing these components is to account for imperfect detection when surveying for the species. Studies that do not account for imperfect detection can often lead to an underestimation of the true proportion of sites occupied and can bias assessments and efforts (MacKenzie et al. 2002, pp. 22482255; MacKenzie et al. 2004, pp. 149-172). The KSNPC and KFO propose to address these concerns by meeting the following objectives: Estimate occupancy and detection probability of the focal species; Estimate the proportion of sites occupied by the focal species, after accounting for the detection probability; Draw inference into the environmental resources important to the persistence of the focal species; Assess the status of the focal species; Estimate the population size of the species within the study area; and Make recommendations for future efforts in the conservation of the focal species.

- Eastern Kentucky University (EKU) and KFO Movement Study and Population Estimate: The KFO is working with EKU (Dr. Sherry Harrel and graduate student, Mr. Jonathan Baxter) to develop and implement a movement study, habitat characterization, and population estimate of two Kentucky arrow darter streams, Gilberts Big Creek and Elisha Creek (DBNF), in Clay and Leslie Counties (Harrel and Baxter 2012, pp. 1-12). Mr. Baxter will use PIT-tags and placed antenna systems to monitor intra- and inter-tributary movement patterns in both streams, and he will be collecting seasonal (spring, summer, and fall) biotic and abiotic data from 17 100-m reaches to determine habitat use and population density/size for both streams.
- Landscape Model of KAD Occurrence in Response to Water Quality: Through USFWS-USGS Quick Response funding, the Kearneysville, West Virginia USGS office and KFO are working cooperatively to apply spatial statistical modeling techniques to estimate Kentucky arrow darter distribution and sensitivity to water quality parameters (Hitt and Floyd 2012, pp. 1-7). The study has three specific objectives: (1) Evaluate stream conductivity relations to land use in the study area using spatial analysis and modeling techniques; (2) Assess potential threshold responses of Kentucky arrow darter occurrence to conductivity and other water quality parameters; and (3) Develop and test spatially explicit species distribution models for Kentucky arrow darter using an integrated fish and water quality dataset from KDFWR and USFWS.
- Bullskin Creek Restoration, Leslie County: A 0.55-km (1823-ft) stream restoration/enhancement project was completed in 2005 in the upper reaches of Bullskin Creek, Leslie County. Bullskin Creek represents suitable habitat for the Kentucky arrow darter and the subspecies was reported from the Bullskin Creek watershed as recently as 2007, when 2 individuals were collected approximately 12.1 stream km [7.5 mi] downstream of the restoration site (Thomas 2008, p. 4). The Bullskin project was funded through Kentuckys Wetland and Stream Mitigation Fund (managed by KDFWRs Stream and Wetland Restoration Program) and was intended to repair eroding banks and poor habitat conditions within Bullskin Creek. The project included a permanent, 9-m (30-foot) easement held by KDFWR. Habitat improvements in this reach of Bullskin Creek will benefit Kentucky arrow darters living in upstream and downstream reaches.

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES This species does not have a final recovery plan. While completing this status review, we have identified the following potential recovery activities which are included below. Recovery Activities • Continue to utilize existing legislation and regulations to protect the species and its habitats (e.g., Act, federal and state surface mining laws, Clean Water Act, state water quality regulations). • Continue to protect, restore, and enhance habitat quality across the species’ range. Federal, state, and private parties should continue to work cooperatively (through Farm Bill programs, Partners for Fish and Wildlife projects, Kentucky Wild Rivers Program, etc.) to restore and protect habitats for the species. Monitoring and Research Activities • Conduct periodic monitoring (five-year intervals) of extant populations and search for new populations in least-disturbed watersheds. • Consult with agency partners and species experts to determine which biological or ecological studies are needed to better understand the species’ life history and sensitivity to threats (e.g., elevated conductivity). Using this information, determine what management strategies are needed to improve the species’ status across its range. • Continue research on population genetics; evaluate gene flow and genetic diversity across the species’ range. • Investigate the effects of catastrophic July 2022 flooding on the Kentucky arrow darter and its habitats in Breathitt, Clay, Knott, Leslie, Owsley, and Perry counties (USFWS, 2022).

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SPECIES ACCOUNT: *Etheostoma susanae* (Cumberland darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; Southeast Region (R4) (USFWS, 2015)

Physical Description

The Cumberland darter (Etheostoma (=Boleosoma) susanae (Jordan and Swain)) is a medium-sized member of the fish tribe Etheostomatini (family Percidae) that reaches over 2 inches (5.5 cm) standard length (SL) (length from tip of snout to start of the caudal peduncle (slender region extending from behind the anal fin to the base of the caudal fin)) (Etnier and Starnes, 1993). The species has a straw-yellow background body color with brown markings that form six evenly spaced dorsal (back) saddles and a series of X-, C-, or W-shaped markings on its sides (Etnier and Starnes, 1993). During spawning season, the overall color of breeding males darkens, and the side markings become obscure or appear as a series of blotches (Etnier and Starnes, 1993).

Taxonomy

MtDNA data support the recognition of Etheostoma susanae and E. nigrum as distinct species (Strange 1998). Page and Burr (2011) included susanae as a subspecies of E. nigrum. USFWS (2011) recognized E. susanae as a species. (NatureServe, 2015)

Historical Range

Not Available

Current Range

The Cumberland darter is endemic to the upper Cumberland River system above Cumberland Falls in Kentucky and Tennessee (O'Bara, 1988; O'Bara, 1991; Etnier and Starnes, 1993). Currently, the Cumberland darter is known from 15 localities in a total of 13 streams in Kentucky (McCreary and Whitley Counties) and Tennessee (Campbell and Scott Counties). All 15 extant occurrences of the Cumberland darter are restricted to short stream reaches, with the majority believed to be restricted to less than 1 mile (1.6 km) of stream (O'Bara, 1991; Thomas, 2007). These occurrences are thought to form six population clusters (Bunches Creek, Indian Creek, Marsh Creek, Jellico Creek, Clear Fork, and Youngs Creek), which are geographically separated from one another by an average distance of 19 stream miles (30.5 km) (O'Bara, 1988; O'Bara, 1991; Thomas, 2007). Based on collection efforts by O'Bara (1991), Laudermilk and Cicerello (1998), and Thomas (2007), the species appears to be extirpated from 11 historical collection sites and a total of nine streams: Cumberland River mainstem, near the mouth of Bunches Creek and Cumberland Falls (Whitley County); Sanders Creek (Whitley County); Brier Creek (Whitley County); Kilburn Fork of Indian Creek (McCreary County); Bridge Fork (McCreary County); Marsh Creek, near mouth of Big Branch and Caddell Branch (McCreary County); Cal Creek (McCreary County); Little Wolf Creek (Whitley County); and Gum Fork (Scott County, TN).

Critical Habitat Designated

Yes; 10/16/2012.

Legal Description

On October 16, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Etheostoma susanae (Cumberland darter) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes 15 critical habitat units (CHUs) in Kentucky and Tennessee (77 FR 63604-63668).

Critical Habitat Designation

The critical habitat designation for Etheostoma susanae includes 15 CHUs in McCreary and Whitley Counties, Kentucky, and Campbell and Scott Counties, Tennessee (77 FR 63604-63668).

Units 1 and 2: Bunches Creek and Calf Pen Fork, Whitley County, Kentucky. (i) Unit 1 includes 5.8 river kilometers (rkm) (3.6 river miles (rmi)) of Bunches Creek from the Seminary Branch and Amos Falls Branch confluence downstream to its confluence with the Cumberland River.

Unit 2 includes 2.9 rkm (1.8 rmi) of Calf Pen Fork from its confluence with Polly Branch downstream to its confluence with Bunches Creek.

Unit 3: Youngs Creek, Whitley County, Kentucky. (i) Unit 3 includes 7.4 rkm (4.6 rmi) of Youngs Creek from Brays Chapel Road downstream to its confluence with the Cumberland River.

Units 4, 5, 6, 7, and 8: Barren Fork, Indian Creek, Cogur Fork, Kilburn Fork, and Laurel Fork, McCreary County, Kentucky. (i) Unit 4 includes 6.3 rkm (3.9 rmi) of Barren Fork from its confluence with an unnamed tributary downstream to its confluence with Indian Creek.

(ii) Unit 5 includes 4.0 rkm (2.5 rmi) of Indian Creek from its confluence with an unnamed tributary downstream to its confluence with Barren Fork.

(iii) Unit 6 includes 8.6 rkm (5.4 rmi) of Cogur Fork from its confluence with Strunk Branch downstream to its confluence with Indian Creek.

(iv) Unit 7 includes 4.6 rkm (2.9 rmi) of Kilburn Fork from its confluence with an unnamed tributary downstream to its confluence with Laurel Fork.

(v) Unit 8 includes 3.5 rkm (2.2 rmi) of Laurel Fork from its confluence with Toms Fork downstream to its confluence with Indian Creek.

Units 9, 10, and 11: Laurel Creek, Elisha Branch, and Jenneys Branch, McCreary County, Kentucky. (i) Unit 9 includes 9.4 rkm (5.9 rmi) of Laurel Creek from Laurel Creek Reservoir downstream to its confluence with Jenneys Branch.

(ii) Unit 10 includes 2.1 rkm (1.3 rmi) of Elisha Branch from its confluence with an unnamed tributary downstream to its confluence with Laurel Creek.

(iii) Unit 11 includes 3.1 rkm (1.9 rmi) of Jenneys Branch from its confluence with an unnamed tributary downstream to its confluence with Laurel Creek.

Unit 12: Wolf Creek, Whitley County, Kentucky. (i) Unit 12 includes 6.3 rkm (3.9 rmi) of Wolf Creek from its confluence with Sheep Creek downstream to its intersection with Wolf Creek River Road.

Units 13, 14, and 15: Jellico Creek, Rock Creek, and Capuchin Creek, McCreary and Whitley Counties, Kentucky, and Campbell and Scott Counties, Tennessee. (i) Unit 13 includes 11.5 rkm (7.2 rmi) of Jellico Creek from its confluence with Scott Branch, Scott County, Tennessee, downstream to its confluence with Capuchin Creek, McCreary County, Kentucky.

(ii) Unit 14 includes 6.1 rkm (3.8 rmi) of Rock Creek from its confluence with Sid Anderson Branch downstream to its confluence with Jellico Creek.

(iii) Unit 15 includes 4.2 rkm (2.6 rmi) of Capuchin Creek from its confluence with Hatfield Creek downstream to its confluence with Jellico Creek.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Etheostoma susanae critical habitat consists of five components in Kentucky and Tennessee (77 FR 63604-63668):

(i) Shallow pools and gently flowing runs of geomorphically stable, secondto fourth-order streams with connectivity between spawning, foraging, and resting sites to promote gene flow throughout the species' range.

(ii) Stable bottom substrates composed of relatively silt-free sand and sand-covered bedrock, boulders, large cobble, woody debris, or other cover.

(iii) An instream flow regime (magnitude, frequency, duration, and seasonality of discharge over time) sufficient to provide permanent surface flows, as measured during years with average rainfall, and to maintain benthic habitats utilized by the species.

(iv) Adequate water quality characterized by moderate stream temperatures, acceptable dissolved oxygen concentrations, moderate pH, and low levels of pollutants. Adequate water quality is defined for the purpose of this rule as the quality necessary for normal behavior, growth, and viability of all life stages of the Cumberland darter.

(v) Prey base of aquatic macroinvertebrates, including midge larvae, mayfly nymphs, caddisfly larvae, and microcrustaceans.

Special Management Considerations or Protections

The 15 units we are designating as critical habitat for the Cumberland darter will require some level of management to address the current and future threats to the physical and biological features of the species. Due to their location on the Daniel Boone National Forest (DBNF), at least a portion of 13 of the 15 critical habitat units are being managed and protected under DBNF's Land and Resource Management Plan (LRMP) (United States Forest Service (USFS) 2004, pp. 1–14). The LRMP is implemented through a series of project-level decisions based on appropriate sitespecific analysis and disclosure. It does not contain a commitment to select any specific project; rather, it sets up a framework of desired future conditions with goals, objectives, and standards to guide project proposals. Projects are proposed to solve resource management problems, move the forest environment toward desired future conditions, and supply goods and services to the public (USFS 2004, pp. 1–14). The LRMP contains a number of protective standards that in general are designed to avoid and minimize potential adverse effects to the

Cumberland darter and other federally listed species; however, the DBNF will continue to conduct project-specific section 7 consultation under the Act when their activities may adversely affect streams supporting Cumberland darters. Two of the 15 critical habitat units are located entirely on private property and are not presently under the special management or protection provided by a legally operative plan or agreement for the conservation of the species. Activities in or adjacent to these 15 critical habitat areas may affect one or more of the physical and biological features essential to the Cumberland darter. For example, features in this critical habitat designation may require special management due to threats posed by resource extraction (coal surface mining, silviculture, natural gas and oil exploration activities), agricultural activities (livestock), lack of adequate riparian buffers, presence of perched road culverts or impassable road crossings that restrict fish movement, construction and maintenance of State and county roads, nonpoint source pollution arising from stormwater runoff, and canopy loss caused by infestations of the hemlock woolly adelgid. These threats are in addition to adverse effects of drought, floods, or other natural phenomena. Other activities that may affect physical and biological features in the critical habitat units include those listed in the Effects of Critical Habitat Designation section below. Management activities that could ameliorate these threats include, but are not limited to: Use of BMPs designed to reduce sedimentation, erosion, and bank side destruction; moderation of surface and ground water withdrawals to maintain natural flow regimes; increase of stormwater management and reduction of stormwater flows into the systems; preservation of headwater springs and streams; regulation of offroad vehicle use; removal or replacement of perched culverts or fords that can restrict darter movements and reduce genetic exchange between populations; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the areas we are designating as critical habitat for the Cumberland darter contain the physical or biological features for the species, and that these features may require special management considerations or protection. Special management consideration or protection may be required to eliminate, or to reduce to negligible levels, the threats affecting the physical or biological features of each unit.

Life History

Feeding Narrative

Adult: Feeding habits are unknown but may be similar to that of the closely related species, the Johnny darter (Etheostoma nigrum). Johnny darters are sight feeders, with prey items consisting of midge larvae, mayfly nymphs, caddisfly larvae, and microcrustaceans (Etnier and Starnes, 1993).

Reproduction Narrative

Adult: Little is known regarding the reproductive habits of the Cumberland darter. Thomas (2007) reported the collection of males in breeding condition in April and May, with water temperatures ranging from 59 to 64 degrees Fahrenheit (°F) (15 to 18 degrees Celsius (°C)). Extensive searches by Thomas (2007) produced no evidence of nests or eggs at these sites.

Habitat Narrative

Adult: Little is known about the specific space requirements of the Cumberland darter; however, the species is typically found in low to moderate gradient second- to fourth-order, geomorphically stable streams, where it occupies shallow pools or runs with gentle current over sand or sand-covered bedrock substrates with patches of gravel or debris (O’Bara, 1991;

Thomas, 2007). Geomorphically stable streams transport sediment while maintaining their horizontal and vertical dimensions (width to depth ratio and cross-sectional area), pattern (sinuosity), and longitudinal profile (riffles, runs, and pools), thereby conserving the physical characteristics of the stream, including bottom features such as riffles, runs, and pools and the transition zones between these features. The protection and maintenance of these habitat features accommodate spawning, rearing, growth, migration, and other normal behaviors of the Cumberland darter.

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Dispersal/Migration Narrative

Adult: Distribution patterns – Limited information exists with regard to upstream or downstream movements of Cumberland darters; however, Winn (1958) reported considerable pre-spawn movements for its closest relative, the Johnny darter. In Beer Creek, Monroe County, Michigan, Johnny darters migrated several miles between temporary stream habitats and permanent pools in downstream reaches. Recent capture data for tagged individuals in Cogur Fork, McCreary County, Kentucky, demonstrate that Cumberland darters may make similar movements (Thomas pers. comm. 2010). Individuals tagged and released by the Kentucky Department of Fish and Wildlife Resources (KDFWR) and Conservation Fisheries, Inc. (CFI) traveled distances ranging from 0.2 to 0.4 miles (0.4 to 0.7 km) between their release date of September 22, 2010 and their recapture date of November 9, 2010 (period of 48 days) (Thomas pers. comm. 2010). Over longer periods, it is likely that Cumberland darters can utilize stream reaches larger than 0.4 miles (0.7 km).

Population Information and Trends

Number of Populations:

17 stream segments (USFWS, 2024)

Population Size:

Unknown

Additional Population-level Information:

Based on all survey information available to the Service (Thomas 2007; Yates 2017; Carter 2018, pers. comm.; Thomas and Brandt 2022; Service unpublished data), the species' current distribution is limited to 17 stream segments in Kentucky (McCreary and Whitley counties) and Tennessee (Campbell and Scott counties) (Figure 1; Appendix A). These streams are clustered in nine, isolated stream systems (Bunches Creek, Youngs Creek, Laurel Fork (of Indian Creek), Cogur Fork, Indian Creek, Laurel Creek, Jellico Creek, Wolf Creek, and Laurel Fork (of Clear Fork), which are separated geographically by an average distance of 30.5 stream km (19 mi) (Figure 1) (O'Bara 1988, O'Bara 1991, Thomas 2007). These stream systems correspond to nine proposed management units identified in the species' 2019 recovery plan (Service 2019). The Cumberland Darter is now extirpated from seven historical streams: Brier Creek, Cal Creek, Gum Fork, Little Wolf Creek, Marsh Creek, Sanders Creek, and Watts Creek (USFWS, 2024)

Population Narrative:

Population size – No population estimates or status trends are available for the Cumberland darter; however, Thomas (2007) provided the most recent information on the status and distribution of the species through completion of a range-wide status assessment in the upper Cumberland River drainage in Kentucky. Between June 2005 and April 2007, a total of 47 sites were sampled qualitatively in the upper Cumberland River drainage. All Kentucky sites with historic records were surveyed (20 sites), as well as 27 others having potentially suitable habitat. Surveys by Thomas (2007) produced a total of 51 specimens from 13 localities. Only one of the localities represented a new occurrence record for the species.

Threats and Stressors

Stressor: Habitat loss and degradation
Exposure:
Response:
Consequence:
Narrative: Habitat loss and modification represent significant threats to the Cumberland darter. Severe degradation from sedimentation, physical habitat disturbance, and contaminants threatens the habitat and water quality on which the Cumberland darter depends. Furthermore, these threats from sources of sedimentation and contaminants are imminent and are the result of ongoing projects that are expected to continue indefinitely. As a result of the imminence of these threats, combined with the vulnerability of the remaining small populations to extirpation from natural and manmade threats, we have determined that the present or threatened destruction, modification, or curtailment of the Cumberland darter habitat and range represents a significant threat of high magnitude. We have no information indicating that the magnitude or imminence of this threat is likely to be appreciably reduced in the foreseeable future.

Stressor: Siltation
Exposure:
Response:
Consequence:
Narrative: Sediment is the most common pollutant within the upper Cumberland River system (KDOW, 1996), and the primary sources of sediment include resource extraction (e.g., coal mining, silviculture, natural gas development), agriculture, road construction, and urban development (Waters, 1995; Skelton 1997; KDOW, 2006; Thomas, 2007). Siltation (excess sediments suspended or deposited in a stream) has been shown to abrade and suffocate bottom-dwelling organisms; reduce aquatic insect diversity and abundance; impair fish feeding behavior by altering prey base and reducing visibility of prey; impair reproduction due to burial of nests; and, ultimately, negatively impact fish growth, survival, and reproduction (Waters, 1995; Knight and Welch, 2001). O'Bara (1991) reported that Cumberland darter habitats are very susceptible to siltation because of the habitat's low to moderate gradient, low velocity, and shallow depth and also concluded that siltation was the major limiting factor for the species' continued existence and its ability to colonize new stream systems. Siltation from development-related construction activities is a real threat to stream habitat, as observed during a severe sedimentation event during the fall of 2007 impacting a 5.2-mi (8.4-km 5) reach of Barren Fork in McCreary County, Kentucky (Floyd pers. obs. 2008). Construction activities associated with the development of a 100-acre (40.5-hectare) park site caused excessive sedimentation of two unnamed headwater tributaries of Barren Fork. Successive, large rainfall events in September

and October carried sediment offsite and impacted downstream areas of Barren Fork known to support Cumberland darters (which had not yet been federally listed at that time) and the federally threatened blackside dace. An initial site visit on September 7, 2007 confirmed that sediment had been carried offsite, resulting in significant habitat degradation in the Barren Fork mainstem and ‘‘adverse effects’’ on the blackside dace. Several smaller sediment events then occurred despite federal and state attempts to resolve the issue, and on July 31, 2008 another large rainfall event resulted in another large sedimentation event in two Barren Fork watershed streams.

Stressor: Pollution
Exposure:
Response:
Consequence:
Narrative: Another significant threat to the Cumberland darter is water quality degradation caused by a variety of nonpoint source pollutants. Coal mining represents a major source of these pollutants (O’Bara, 1991; Thomas, 2007) because it has the potential to contribute high concentrations of dissolved metals and other solids that lower stream pH or lead to elevated levels of stream conductivity (Pond, 2004; Mattingly et al., 2005). These impacts have been shown to negatively affect fish species, including listed species, in the Clear Fork system of the Cumberland basin (Weaver, 1997; Hartowicz pers. comm. 2008). The direct effect of elevated stream conductivity on fishes, including the Cumberland darter, is poorly understood, but some species, such as blackside dace, have shown declines in abundance over time as conductivity increased in streams affected by mining (Hartowicz pers. comm., 2008). Studies indicate that blackside dace are generally absent when conductivity values exceed 240 microSiemens (µS) (Mattingly et al., 2005; Black and Mattingly, 2007). Other non-point source pollutants that affect the Cumberland darter include domestic sewage (through septic tank leakage or straight pipe discharges); agricultural pollutants such as fertilizers, pesticides, herbicides, and animal waste; and other chemicals associated with oil and gas development. Non-point source pollutants can cause excess nitrification (increased levels of nitrogen and phosphorus), excessive algal growth, in-stream oxygen deficiencies, increased acidity and conductivity, and other changes in water chemistry that can seriously impact aquatic species (KDOW, 1996; KDOW, 2006).

Stressor: Other natural or manmade factors affecting its continued existence
Exposure:
Response:
Consequence:
Narrative: The Cumberland darter has a limited geographic range and a small population size. The existing populations are extremely localized and geographically isolated from one another, leaving them vulnerable to localized extinctions from intentional or accidental toxic chemical spills, habitat modification, progressive degradation from runoff (non-point source pollutants), natural catastrophic changes to their habitat (e.g., flood scour, drought), and other stochastic disturbances. Potential sources of unintentional spills include accidents involving vehicles transporting chemicals over road crossings of streams or the accidental or intentional release of chemicals used in agricultural or residential applications into streams. Like most other darters, the Cumberland darter depends on perennial stream flows that create suitable habitat conditions needed for successful completion of its life cycle. An ample supply of flowing water provides a means of transporting nutrients and food items, moderating water temperatures and dissolved oxygen levels, removing fine sediments that could damage spawning or foraging habitats, and

diluting nonpoint source pollutants. Water withdrawals do not represent a significant threat to the species, but the species is faced with occasional low-flow conditions that occur during periods of drought. One such event occurred in the summer and fall of 2007, when recorded streamflows in the upper Cumberland River basin of Kentucky and Tennessee (USGS Station Number 03404000) in September and October of 2007 were among the lowest recorded monthly values (99th percentile for low-flow periods) during the last 67 years (Cinotto pers. comm. 2008). Thomas et al. (2004) report that the frequency, duration, and intensity of droughts, such as the one that occurred in 2007, are likely to increase in the Southeast as a result of global climate change. Species that are restricted in range and population size are also more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression, decreasing their ability to adapt to environmental changes, and reducing the fitness of individuals (Soule, 1980; Hunter, 2002; Allendorf and Luikart, 2007). It is likely that some of the Cumberland darter populations are below the effective population size required to maintain long-term genetic and population viability (Soule, 1980; Hunter, 2002). The long-term viability of a species is founded on the conservation of numerous local populations throughout its geographic range (Harris, 1984). These separate populations are essential for the species to recover and adapt to environmental change (Noss and Cooperrider, 1994; Harris, 1984). The level of isolation seen in this species makes natural repopulation following localized extirpations virtually impossible without human intervention.

Stressor: Reduced Range:
Exposure:
Response:
Consequence:
Narrative: Reduced Range The Cumberland Darter has a limited geographic range and occurs in low densities in streams across its range. Existing populations are extremely localized and geographically isolated from one another, leaving them extremely vulnerable to localized extinctions from intentional or accidental toxic chemical spills, habitat modification, progressive degradation from land surface runoff (nonpoint-source pollutants), natural stochastic events (e.g., floods, drought), and decreased fitness from reduced genetic diversity. Potential sources of accidental spills include accidents involving vehicles transporting chemicals over road crossings of streams inhabited by this species and accidental or intentional release of chemicals used in agricultural or residential applications. Road crossings of streams (e.g., culverts) can contribute to the isolation and even local extirpation of small stream fishes like the Cumberland Darter, particularly when the downstream end of the culvert is perched above the streambed (Benton et al. 2008). Any physical barrier that reduces or eliminates connectivity among populations can be a threat because it does not allow for natural recolonization of upstream reaches following stochastic disturbance (e.g., floods, drought). The influence of these culverts can be significant, as areas upstream and downstream of these barriers can have striking faunal differences (Eisenhour and Floyd 2012). 14 Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression, decreasing their ability to adapt to environmental changes, and reducing the fitness of individuals (Soule 1980, Hunter 2002, Allendorf and Luikart 2007). Some Cumberland Darter populations could be below the effective population size required to maintain long-term genetic and population viability (Soule 1980, Hunter 2002). The long-term viability of a species is founded on the conservation of numerous local populations throughout its geographic range (Harris 1984). These separate populations are essential for the species to recover and adapt to environmental change (Noss and Cooperrider 1994, Harris 1984).

The level of isolation seen in this species makes natural repopulation following localized extirpations virtually impossible without human intervention (USFWS, 2018a).

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: In its Fifth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) concluded that warming of the climate system is unequivocal (IPCC 2014). Numerous long-term climate changes have been observed including changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones (IPCC 2014). Species that are dependent on specialized habitat types, limited in distribution, or at the extreme periphery of their range may be most susceptible to the impacts of climate change (see 75 FR 48911, August 12, 2010); however, while continued change is certain, the magnitude and rate of change is unknown in many cases. Climate change has the potential to increase the vulnerability of the Cumberland Darter to random catastrophic events (McLaughlin et al. 2002, Thomas et al. 2004). An increase in both severity and variation in climate patterns is expected, with extreme floods, strong storms, and droughts becoming more common (Cook et al. 2004, Ford et al. 2011, IPCC 2014). Thomas et al. (2004) report that frequency, duration, and intensity of droughts are likely to increase in the Southeast as a result of global climate change. Predicted impacts of climate change on fishes include disruption to their physiology (such as temperature tolerance, dissolved oxygen needs, and metabolic rates), life history (such as timing of reproduction, growth rate), and distribution (range shifts, migration of new predators) (Jackson and Mandrak 2002, Heino et al. 2009, Strayer and Dudgeon 2010, Comte et al. 2013). According to Kaushal et al. (2010), stream temperatures in the Southeast have increased roughly 0.2–0.4o C (0.4–0.7o F) per decade over the past 30 years, and as air temperature is a strong predictor of water temperature, stream temperatures are expected to continue to rise. Estimates of the effects of climate change using available climate models typically lack the geographic precision needed to predict the magnitude of effects at a scale small enough to discretely apply to the range of a given species. However, data on recent trends and predicted changes for Kentucky and Tennessee (Girvetz et al. 2009), and, more specifically, the upper Cumberland River drainage (Alder and Hostetler 2017), provide some insight for evaluating the potential threat of climate change to the Cumberland Darter. Alder and Hostetler (2017, entire) use different emission scenarios to calculate estimates of average annual increases in maximum and minimum temperature, precipitation, snowfall, and other variables. These scenarios, called “representative concentration pathways” (RCPs) are plausible pathways toward reaching a target radiative forcing (the change in energy in the atmosphere due to greenhouse gases) by the year 2100 (Moss et al. 2010). Depending on the chosen model and emission scenario (RCP 8.5 (high) vs. 4.5 (moderate)), annual mean maximum temperatures for the Cumberland River drainage are expected to increase by 2.2 to 3.3o C (3.8 to 5.9o F) by 2074, while precipitation models predict that the Cumberland River drainage will experience a slight increase in annual mean precipitation (0.5 cm/month (0.2 in/month)) through 2074 (Girvetz et al. 2009, Alder and Hostetler 2016). There is uncertainty about the specific effects of climate change (and their magnitude) on the Cumberland Darter; however, climate change is almost certain to affect aquatic habitats in the upper Cumberland River drainage of Kentucky and Tennessee through increased water temperatures and more frequent droughts (Alder and Hostetler 2017, entire), and species with limited ranges, fragmented distributions, and small population size are

thought to be especially vulnerable to the effects of climate change (Byers and Norris 2011). Thus, we consider climate change to be a potential threat to the Cumberland Darter (USFWS, 2018a)

Recovery

Reclassification Criteria:
Recovery Priority Number: 5 (USFWS, 2024)

Delisting Criteria:
Delisting : 1) Management Uni ts 1-9 or Management Units 1- 7, 9, and one additional stream within the species' his torical range (e.g., Sanders Creek) are determined to be protected from present and foreseeable habitat threats through recovery efforts such as land acquisition, conservation agreements and easements, stewardship, habitat restoration, outreach, adequate regulatory oversight and enforcement, or other similar actions1; 2) Instream habitat quality (substrate, flows, water quality) in these management units is sufficient, as defined by recovery tasks 3.1 and 3.2, to meet the species' life history requirements; and 3) A viable population2 must occur within each of these management units (USFWS, 2019).

Recovery Actions:

- There is currently no recovery plan for the Cumberland darter. There is a “Recovery Outline” for the species that outlines a preliminary course of action for the recovery of the Cumberland darter (Etheostoma susanae) until a comprehensive recovery plan for the species is approved (USFWS KFO, 2011). The outline describes the Service’s intent to work with cooperators to implement ongoing conservation actions for the Cumberland darter including control of livestock access through fencing and alternative water sources; protection, enhancement, or restoration of riparian habitats through easements, stream buffer establishment and maintenance, installation and maintenance of erosion control measures, and foregoing detrimental land use practices; protection, enhancement, or restoration of aquatic habitats through stream easements, stream de-channelization, installation of in-stream habitat features, stream bank stabilization, and road crossing stabilization; and species propagation and reintroduction.
- Recovery Priority Number 5 (USFWS, 2018a).
- Actions Needed (see the associated Recovery Implementation Strategy for stepped down actions): (1) Conserve, protect, and restore existing populations and habitats (Priority 1)3. Habitat loss is the primary cause of range curtailment of the Cumberland Darter. Habitats throughout the species' range have been modified and degraded by a variety of human-induced impacts such as siltation, water pollution, loss of riparian corridors, and changes in channel morphology. Because of these impacts and potential barriers to dispersal, the species has been extirpated from numerous streams and now occurs in nine isolated watersheds. Habitats within these remaining watersheds must be protected and enhanced to meet the species' life history requirements and to ensure the species' long-term survival and viability. (2) Conduct research to determine the species' status, demographics, population genetics, and trends (Priority 1). A monitoring program is needed to track the species' status, document the species' population structure and genetics, characterize habitat conditions, and determine the effectiveness of recovery actions. Research is needed to evaluate genetic differences across the species' range. These data are essential for defining reproductive exchange (flow) across the range, genetic diversity, hybridization, and

genetically meaningful recovery progress. Other potentially suitable habitats within the species' range but outside of the management units, especially those on the DBNF, should be searched for undocumented populations or unoccupied suitable habitats. (3) Document the species' life history, habitat requirements, and threat sensitivity (Priority 2). Little is known regarding the species' life history, microhabitat requirements, and threat sensitivity. Defining these requirements with controlled studies will help us protect populations, guide Federal and State coordination and permit review, and focus conservation and restoration efforts throughout the species' range. (4) Establish a propagation plan for the species that allows for the reintroduction of the species to new habitats (Priority 2). Two significant threats to the Cumberland Darter are its small population size and the isolated nature of its nine populations. A continuation and expansion of the current captive propagation and reintroduction program initiated by KDFWR; Conservation Fisheries, Inc. (CFI); and the Service is needed to expand the species' current range, improve connectivity among populations, and protect against stochastic and catastrophic events. CFI is the only facility that has worked with this species in the past, but Service fish hatcheries could provide a potential supporting role at some point in the future. (5) Coordinate all activities and conduct periodic review of recovery progress and strategy (Priority 3). The recovery plan, the species biological report, its action items, and its implementation schedule, should be evaluated periodically to determine if the objectives are being achieved, and to incorporate new information or necessary modifications. The species will be monitored under Tasks 2.1, 2.2, and 4.4. Changes in distribution and habitat quality should be used to focus recovery efforts and adjust priorities as needed. (6) Increase public awareness of the species through outreach materials (Priority 3). This action would include the development of web-based educational materials, as well as the distribution of fact sheets and other outreach materials within the upper Cumberland River drainage. Outreach efforts by the Service (PFW Program), KDFWR (Stream and Wetland Mitigation Program, Kentucky Afield magazine and TV program), TWRA (Tennessee Wildlife magazine, Tennessee Wild Side TV program), NRCS (Farm Bill programs), and KDOF (Master Logger program) should incorporate information on the species' biology, status, distribution, and threats (USFWS, 2019).

- RECOMMENDATIONS FOR FUTURE ACTIONS Recommendation: Complete a final recovery plan. A draft recovery plan was published in the Federal Register on April 3, 2018, with a 60-day public comment period. We anticipate the recovery plan to be finalized in early 2019. Recommendations for specific recovery actions: The following recovery actions should be made a priority over the next five years: 1. Continue to protect, restore, and enhance habitat quality throughout the range of the species. Federal, state, and private parties should continue to work cooperatively (through Farm Bill programs, Partners for Fish and Wildlife projects, etc.) to restore and protect habitats. 2. Conduct quantitative surveys in each occupied stream to determine the population size for each management unit identified in the draft recovery plan. Quantitative methods should follow those of Yates (2017). 3. Continue research efforts on population genetics; use results of the TNACI genetics study to inform recovery efforts. 4. Conduct a life history study for the species. 5. Develop a propagation plan for the species that allows for reintroduction of the species to new habitats and expansion of the species’ current range. 6. Increase public awareness of the species through outreach efforts, including web-based educational materials, fact sheets, regional publications, and media sources such as public television (USFWS, 2018a).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES We have identified the following recovery, monitoring, and research activities: Recovery Activities ● Continue to utilize existing legislation and regulations to protect the species and its habitats (e.g., Act, federal and state surface mining laws, Clean Water Act, state water quality regulations). ● Continue to protect, restore, and enhance habitat quality across the species' range. Federal, state, and private parties should continue to work cooperatively (through Farm Bill programs, Partners for Fish and Wildlife projects, Kentucky Wild Rivers Program, etc.) to restore and protect habitats for the species. Monitoring and Research Activities ● Conduct quantitative surveys in each occupied stream to estimate population size. ● Consult with agency partners and species experts to determine what biological or ecological studies are needed to better understand the species' life history and sensitivity to threats (e.g., sedimentation). Using this information, determine what management strategies are needed to improve the species' status across its range. ● Continue research on population genetics; evaluate gene flow and genetic diversity across the species' range. ● Conduct a life history study for the species. ● Evaluate the potential for reintroduction of the species into historical habitats. Assess habitat and water quality conditions in these streams and determine which streams are suitable for reintroduction efforts (USFWS, 2024).

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SPECIES ACCOUNT: *Etheostoma trisella* (Trispot darter)

Species Taxonomic and Listing Information

Listing Status: Threatened; January 28, 2019 [USFWS 2018]

Taxonomy

The trispot darter was described by Bailey and Richards (1963, p. 14) from a single specimen collected in Cowans Creek, 6.7 miles southeast of Centre, Cherokee County, Alabama on September 13, 1947. This species was originally described as a member of the subgenus Psychromaster and was later moved to the subgenus Ozarka in 1980 (Williams and Robinson, p. 150). In 2011 the trispot darter was moved into the Etheostoma subgenus where it exists today (Near et al. 2011, p. 593) (USFWS, 2017).

Historical Range

All known records of the trispot darter occur above the Fall Line in the Ridge and Valley ecoregion of Alabama, Georgia, and Tennessee. The type locality is a single specimen from Cowan's Creek, Coosa River tributary, Cherokee County, Alabama, collected in 1947, and was described in 1963, by Bailey and Richards (1963, p. 14). The type locality has been inundated by Weiss Lake, in 1960, and the species was assumed extinct at the time it was described (Bailey and Richards 1963, p. 18). The historical range (Figure 2-3) is delineated from known collections of trispot darter within the Coosa Basin, based on Hydrologic Unit Codes (HUC8) watersheds, in the Ridge and Valley ecoregion. This fish has a historical range from the middle to upper Coosa River Basin with collections in the mainstem Coosa, Conasauga, and Coosawattee rivers, their tributaries, and tributaries to the Oostanaula River. Genetics indicate that this species has a wide extent in the Coosa River Basin and ranged from at least the Little Canoe Creek system near Springville, Alabama to the Upper Conasauga River near Conasauga, Tennessee (Figure 2-1) (USFWS, 2017).

Current Range

AL, GA, TN; Currently, the trispot darter is known to occur in Little Canoe Creek and tributaries (including Gin Branch), Ballplay Creek tributaries, Conasauga River and tributaries (including Holly, Coahulla, and Mill (GA) creeks, and a Mill Creek (TN) tributary,) and Coosawattee River and tributary (including Salacoa Creek) (USFWS, 2017).

Critical Habitat Designated

Yes;

Critical Habitat Designation

Trispot Darter (Etheostoma Trisella) (1) Critical habitat units are depicted for St. Clair, Etowah, Cherokee, and Calhoun Counties, Alabama; Bradley and Polk Counties, Tennessee; and Whitfield, Murray, and Gordon Counties, Georgia, on the maps in this entry. (2) Within these areas, the physical or biological features essential to the conservation of the trispot darter consist of the following components: (i) Geomorphically stable, small to medium streams with detritus, woody debris, and stands of water willow (Justicia americana) over stream substrate that consists of small cobble, pebbles, gravel, and fine layers of silt; and intact riparian cover to maintain stream morphology and reduce erosion and sediment inputs. (ii) Adequate seasonal water flows, or a hydrologic flow regime (which includes the severity, frequency, duration, and seasonality of discharge over time) necessary to maintain appropriate benthic habitats and to maintain and create connectivity between permanently flowing streams with associated streams that hold water from November through April, providing connectivity between the darter's spawning and summer areas. (iii) Water and sediment quality (including, but not limited to, conductivity; hardness; turbidity; temperature; pH; ammonia; heavy metals; pesticides; animal waste products; and nitrogen, phosphorus, and potassium fertilizers) necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages. (iv) Prey base of aquatic macroinvertebrates. (3) Critical habitat does not include manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located existing within the legal boundaries on October 30, 2020. In addition, any lands that are perennially dry areas that are located within the critical habitat boundaries shown on the maps in this entry are not designated as critical habitat. (USFWS, 2020)

Primary Constituent Elements/Physical or Biological Features

We derive the specific physical or biological features essential to the conservation of trispot darter from studies of this species' habitat, ecology, and life history. Additional information can be found in the October 4, 2017, proposed listing rule (82 FR 46183); the December 28, 2018, final listing rule (83 FR 67131); the December 28, 2018, proposed critical habitat rule (83 FR 67190); and the SSA report (Service 2018, entire). We have determined that the following physical or biological features are essential to the conservation of trispot darter: (1) Geomorphically stable, small to medium streams with detritus, woody debris, and stands of water willow (Justicia americana) over stream substrate that consists of small cobble, pebbles, gravel, and fine layers of silt; and intact riparian cover to maintain stream morphology and reduce erosion and sediment inputs. (2) Adequate seasonal water flows, or a hydrologic flow regime (which includes the severity, frequency, duration, and seasonality of discharge over time) necessary to maintain appropriate benthic habitats and to maintain and create connectivity between permanently flowing streams with associated streams that hold water from November through April, providing connectivity between the darter's spawning and summer areas. (3) Water and sediment quality (including, but not limited to, conductivity; hardness; turbidity; temperature; pH; ammonia; heavy metals; pesticides; animal waste products; and nitrogen, phosphorus, and potassium fertilizers) necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages. (4) Prey base of aquatic macroinvertebrates. (USFWS, 2020)

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features that are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the trispot darter may require special management considerations or protections to reduce the following threats: (1) Urbanization of the landscape, including (but not limited to) land conversion for urban and commercial use, infrastructure (roads, bridges, utilities), and urban water uses (water supply reservoirs, wastewater treatment); (2) nutrient pollution from agricultural activities that impact water quantity and quality; (3) significant alteration of water quality; (4) improper forest management or silviculture activities that remove large areas of forested wetlands and riparian systems; (5) culvert and pipe installation that creates barriers to movement; (6) changes and shifts in seasonal precipitation patterns as a result of climate change; (7) other watershed and floodplain disturbances that release sediments or nutrients into the water or fill suitable spawning habitat;

and (8) creation of reservoirs that convert permanently flowing streams and/or streams that hold water from November through April into lake or pond-like (lentic) environments. Management activities that could ameliorate these threats include, but are not limited to, use of best management practices (BMPs) designed to reduce sedimentation, erosion, and bank-side destruction; protection of riparian corridors and suitable spawning habitat; retention of sufficient canopy cover along banks; moderation of surface and ground water withdrawals to maintain natural flow regimes; increased use of stormwater management and reduction of stormwater flows into the stream systems; placement of culverts or bridges that accommodate fish passage; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. (USFWS, 2020)

Life History

Reproduction Narrative

Adult: This darter species spawns during winter months (January - March), has a 1:1 sex ratio, and has a distinct spawning habitat separate from its non-breeding habitat. Individuals congregate within the spawning areas and rainfall is most likely the primary trigger for movement into spawning grounds (Ryon 1981, p. 47). As described above males develop breeding colors and may have some growth of breeding projections on their head, body, or fins. In December and early January the ovaries of sexually mature females grow quickly. This fish lives a maximum of three years but most likely dies after the end of their second year (Ryon 1981, p. 69). Not all of the first year age class matured fast enough to spawn in Ryon's study and he found individuals within the breeding habitat that did not show mature eggs or enlarged ovaries. The upper estimate of eggs (developing and mature) for spawning females at the beginning of spawning season is 292. Females arriving early to the spawning areas may spawn twice a year (Ryon 1986, p. 80). It has been speculated that if the trispot darter has one to two years of low reproductive success it could result in local extirpations due to its short life span and low fecundity (Ryon 1981, p. 71). Trispot darters have adhesive eggs that attach to vegetation or rocky substrates and once laid, the eggs are abandoned. The eggs have an incubation period of approximately 30 days at 53° F (12° C). Development from egg to larvae is 41 days (Table 1-1) (Ryon 1981, p. 59) (USFWS, 2017). Breeding Season Habitat: In late fall this migratory species shifts its habitat preference and movement toward spawning areas begins; this movement may be queued by temperature change, precipitation, and/or decreasing daylight hours (Ryon 1981, p. 13), with rainfall being the most likely trigger (Ryon 1981, p. 47). The fish move from the main channels into tributaries and eventually reach adjacent seepage areas where they will congregate and remain from approximately late November or early December to late April. Breeding habitat becomes available as precipitation increases and the water table rises. The transition zone between breeding and non-breeding habitats was described by Ryon (ibid) to be a low gradient stream mostly comprised of long pools with woody debris and clay substrate base overlayed with silt and sand. Non biting midges (Chrionomidae) were also found to be the dominate prey item while in breeding areas, followed by mayflies (Ephemeroptera) nymphs (Ryon 1986, p. 76). Breeding sites have been defined as intermittent to partially intermittent seepage areas and ditches with little to no flow; shallow depths (12 inches, 30 cm or less); moderate leaf litter covering mixed cobble, gravel, sand, and clay; a deep layer of soft silt over clay; and emergent vegetation (both aquatic and terrestrial species) (Ryon 1981, p. 15 - 17 and 1986, p. 75, O'Neil et al. 2009, p. 18). The temperature of the spawning areas likely remains fairly constant during the breeding period (53 to 59° F, 12 to 15° C) (Ryon 1981, p. 66). During their spawning period the trispot darter requires seasonally wet tributaries and seeps that become available and connected to their non-breeding habitat through precipitation and a rise in the water table. Breeding habitat preference was found to be similar in the Little Canoe Creek population and the Conasauga River population (O'Neil et al. 2009, p. 18) (USFWS, 2017).

Dispersal/Migration

Motility/Mobility

Adult: High (USFWS, 2017)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Migratory (USFWS, 2017)

Population Information and Trends

Number of Populations:

4 MU's (USFWS, 2017)

Population Narrative:

Currently, the trispot darter is known to occur in Little Canoe Creek, Ballplay Creek tributaries, Conasauga River and tributaries, and Coosawattee River and tributary. For the purposes of this report we considered three historical Management Units (MU's) (Cowans Creek system, Johns Creek system, and Woodward Creek system) and four current MU's for the trispot darter (Little Canoe Creek System, Ballplay Creek System, Conasauga River System, and Coosawattee River System). Historical MU's were defined as one or more watersheds that the species was collected in prior to 2007. Current MU's were defined as one or more watersheds that the species currently occupies (collections 2007-2017) and were grouped based on similar management strategy requirements and genetic research. Currently, the trispot darter occupies approximately 20% of its historically known range. • Resiliency describes the ability of populations to withstand stochastic events (arising from random factors). To be resilient to stochastic events populations of trispot darters need to have a large number of individuals (abundance), cover a large area (spatial extent), and the area occupied needs to occur in multiple non-linear waterways (spatial complexity). Additionally, populations need to exist in locations where environmental conditions provide suitable habitat and water quality such that adequate numbers of individuals can be supported. Without all of these factors, a population has an increased likelihood for localized extirpation. The tripsot darter currently has low resiliency in each of the four management units considered in our analysis. • Representation describes the ability of a species to adapt to changing environmental conditions. For the trispot darter to exhibit adequate representation, resilient populations should occur in the ecoregion to which it is native (Ridge and Valley); these populations should occur at the widest extent possible across the historic range of the species; and they should occupy multiple tributaries in addition to the core population within the mainstem of a river. Finally, natural levels of connectivity should be maintained between representative populations because it allows for the exchange of novel and beneficial adaptations where connectivity is high or is the mechanism for localized adaption and variation where connectivity is lower and the species is naturally more isolated. The trispot darter currently has low representation across its range in the Ridge and Valley ecoregion. • Redundancy describes the ability of a species to withstand catastrophic events. Redundancy for the trispot darter is characterized by having multiple, resilient and representative populations distributed within the species' ecological setting and across its range. For this species to exhibit redundancy, it must have multiple resilient populations with connectivity maintained among them. Connectivity allows for immigration and emigration between populations and increases the likelihood of recolonization should a population become extirpated. Redundancy was found to be low in the range of the trispot darter (USFWS, 2017).

Threats and Stressors

Stressor: Reduced Connectivity
Exposure:
Response:
Consequence:
Narrative: The major threat to this species is reduced connectivity between the non-breeding habitat and the breeding habitat during spawning season that may occur due to excess groundwater withdrawal, drought, or made made structures such as dams and improper road crossings (USFWS, 2017).

Recovery

Conservation Measures and Best Management Practices:

- Trispot darter (Etheostoma trisella). (1) Prohibitions. The following prohibitions that apply to endangered wildlife also apply to the trispot darter. Except as provided under paragraph (q)(2) of this section and §§ 17.4 and 17.5, it is unlawful for any person subject to the jurisdiction of the United States to commit, to attempt to commit, to solicit another to commit, or cause to be committed, any of the following acts in regard to the trispot darter: (i) Import or export, as set forth at § 17.21(b) for endangered wildlife. (ii) Take, as set forth at § 17.21(c)(1) for endangered wildlife. (iii) Possession and other acts with unlawfully taken specimens, as set forth at § 17.21(d)(1) for endangered wildlife. (iv) Interstate or foreign commerce in the course of commercial activity, as set forth at § 17.21(e) for endangered wildlife. (v) Sale or offer for sale, as set forth at § 17.21(f) for endangered wildlife. (2) Exceptions from prohibitions. In regard to this species, you may: (i) Conduct activities as authorized by a permit issued under § 17.32. (ii) Take, as set forth at § 17.21(c)(2) through (c)(4) for endangered wildlife. (iii) Take, as set forth at § 17.31(b). (iv) Take incidental to an otherwise lawful activity caused by: (A) Species restoration efforts by State wildlife agencies, including collection of broodstock, tissue collection for genetic analysis, captive propagation, and subsequent stocking into currently occupied and unoccupied areas within the historical range of the species. (B) Channel restoration projects that create natural, physically stable, ecologically functioning streams (or stream and wetland systems) that are reconnected with their groundwater aquifers and, if the projects involve known trispot darter spawning habitat, that take place between May 1 and December 31. These projects can be accomplished using a variety of methods, but the desired outcome is a natural channel with low shear stress (force of water moving against the channel); bank heights that enable reconnection to the floodplain; a reconnection of surface and groundwater systems, resulting in perennial flows in the channel; riffles and pools comprised of existing soil, rock, and wood instead of large imported materials; low compaction of soils within adjacent riparian areas; and inclusion of riparian wetlands. (C) Streambank stabilization projects that utilize bioengineering methods to replace pre-existing, bare, eroding stream banks with vegetated, stable stream banks, thereby reducing bank erosion and instream sedimentation and improving habitat conditions for the species. Stream banks may be stabilized using live stakes (live, vegetative cuttings inserted or tamped into the ground in a manner that allows the stake to take root and grow), live fascines (live branch cuttings, usually willows, bound together into long, cigarshaped bundles), or brush layering (cuttings or branches of easily rooted tree species layered between successive lifts of soil fill). Stream banks must not be stabilized solely through the use of quarried rock (rip-rap) or the use of rock baskets or gabion structures. (D) Silviculture practices and forest management activities that: (1) Implement State best management practices, particularly for streamside management zones, for stream crossings, for forest roads, for erosion control, and to maintain stable channel morphology; or (2) Remove logging debris or any other large material placed within natural or artificial wet weather conveyances or ephemeral, intermittent, or perennial stream channels; and (3) When such activities involve trispot darter spawning habitat, are carried out between May 1 and December 31. (E) Transportation projects that provide for fish passage at stream crossings that are performed between May 1 and December 31 to avoid the time period when the trispot darter will be found within spawning habitat, if such habitat is affected by the activity. (F) Projects carried out in the species' range under the Working Lands for Wildlife program of the Natural Resources Conservation Service, U.S. Department of Agriculture, that: (1) Do not alter habitats known to be used by the trispot darter beyond the fish's tolerances; and (2) Are performed between May 1 and December 31 to avoid the time period when the trispot darter will be found within its spawning habitat, if such habitat is affected by the activity. (v) Possess and engage in other acts with unlawfully taken wildlife, as set forth at § 17.21(d)(2) for endangered wildlife (USFWS, 2020a)

References

U.S. Fish and Wildlife Service. 2018. Endangered and Threatened Wildlife and Plants

Threatened Species Status for Trispot Darter. Final Rule. FR Vol. 83, No. 248. Pages 67131-67140. U.S. Fish and Wildlife Service. 2017. Species Status Assessment Report for the Trispot Darter (Etheostoma trisella). Version 1.0. U.S. Fish and Wildlife Service. Region 4. Atlanta, GA. 77 pp.

USFWS. 2020. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for the Trispot Darter. Final Rule. FR Vol. 85, No. 190. Pages 61619-61638.

U.S. Fish and Wildlife Service. 2017. Species Status Assessment Report for the Trispot Darter (Etheostoma trisella). Version 1.0. U.S. Fish and Wildlife Service. Region 4. Atlanta, GA. 77 pp.

USFWS. 2020a. Endangered and Threatened Wildlife and Plants

Section 4(d) Rule for Trispot Darter. Final Rule. FR Vol. 85, No. 190. Pages 61614-61619.

SPECIES ACCOUNT: *Etheostoma wapiti* (Boulder darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; Southeast Region (R4); Entire Experimental Population, Non-Essential; Southeast Region (R4) (USFWS, 2015)

Physical Description

A 2-3-inch fish (darter) (NatureServe, 2015). The body of the male is olive to gray in color with eight to nine dorsal saddles and 10-11 mid-lateral blotches often present, especially in juveniles. There are 10-14 dark horizontal lines between scale rows on the sides of the fish. Red pigmentation may be present near the margins of the first one or two membranes of the spinous dorsal fin on adult females. Red coloration is lacking on fins and the body of adult males with chromatic colors restricted to pale yellow sub-marginal bands on spinous dorsal, soft dorsal, and caudal fins; and pale blue on the gular area, bases of the pelvic fins, and between the anal spines. Males are otherwise dark grey on the body and fins except for the horizontal lines on sides and dark margins on the median fins. Females are lighter in color. Both sexes have a dark gray or black bar beneath the eyes and a dark spot behind the eyes (Etnier, personal communication, 1988; Etnier and Starnes 1993) (USFWS, 2014).

Taxonomy

The species was originally described as Etheostoma wapiti by Etnier and Williams (1989, entire). The genus Nothonotus was previously designated as a subgenus within Etheostoma, but Near and Keck (2005) proposed elevating it to genus, and additional darter phylogenetic studies have supported this (Near et al. 2011). The upcoming edition of the Common and Scientific Names of Fishes from the United States, Canada, and Mexico will include Nothonotus as a genus and the boulder darter will be recognized as Nothonotus wapiti (Dr. Larry Page, Curator of Fishes, Florida Museum, pers. comm. 2022). This name change is currently supported by the Integrated Taxonomic Information System (ITIS 2023) as the valid genus for boulder darter. This updated nomenclature does not impact our assessment of the listed entity, and it is still considered a valid entity by the Service. Until we finalize a technical correction of the name, we will continue to reference the species using the name as it was listed, Etheostoma wapiti (USFWS, 2023).

Historical Range

Historical record exists for Shoal Creek near Florence in Lauderdale County, northern Alabama. In 2004, boulder darters were found in Shoal Creek, just upstream from the embayment of Wheeler Reservoir (Shepard et al. 2006). The species may have occurred in the main channel of the Tennessee River and lower part of the Flint River (Boschung and Mayden 2004). In 2005, USFWS (Federal Register, 8 April 2005) announced that it was planning a reintroduction in Shoal Creek, Lauderdale County, Alabama, and Lawrence County, Tennessee, as a nonessential experimental population (releases have begun). Between 1997 and 2003, Conservation Fisheries, Inc. (CFI), released a total of 2,264 propagated boulder darters into 4 sites in the Elk River (USFWS 2009). (NatureServe, 2015)

Current Range

Range includes the main channel of the Elk River (from Fayetteville to just above Wheeler Reservoir embayment and 0.5 miles below the Alabama State Highway 127 bridge) and a few of its larger tributaries (lower Richland Creek; mouth of Indian Creek, at least formerly) in south-central Tennessee (Giles and Lincoln counties) and Limestone County, northern Alabama (Etnier and Williams 1989, Etnier and Starnes 1993, Boschung and Mayden 2004, USFWS 2009). CFI surveys from 1997 to 2007 indicated that boulder darters are apparently still present at all locations with suitable habitat in the mainstem Elk River, albeit in low numbers. CFI observed boulder darters at three new localities, expanding the known distribution to areas below Harms Mill, at Hobbs Bridge, and at a shoal well above the I-65 Bridge (see USFWS 2009). The Tennessee Wildlife Resources Agency (TWRA)/Frito Lay Access, just upstream from Fayetteville, Tennessee, is the upstream extent of the boulder darter's current known range (USFWS 2009). (NatureServe, 2015)

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Food Habits: Invertivore (Adult, Immature) (NatureServe, 2015). Little is known about its food habits. However, other members of the subgenus Nothonotus feed primarily on immature aquatic insects (Stiles 1972). The species is likely a sight feeder and is therefore probably diurnally active (USFWS, 1989).

Reproduction Narrative

Adult: Male guards eggs (NatureServe, 2015).

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow/Specialist (NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: This darter inhabits fast rocky riffles of small to medium rivers (Williams et al. 1989, Page and Burr 2011). Adults have been found only in areas of boulder/rubble substrate (natural or from broken mill dams and bridges), usually in water 0.6-1.2 meters deep (Etnier and Starnes 1993, Boschung and Mayden 2004); typical habitat probably is deep, rocky, flowing pools in rivers and lower portions of large tributaries (Etnier and Williams 1989). Spawning occurs among boulders in flowing water with a velocity of about 0.3-0.6 m/sec; eggs are laid in clusters in narrow, roughly horizontal spaces between boulders (Burkhead and Williams 1992). Juveniles have been collected from gravel riffles (Etnier and Starnes 1993) (NatureServe, 2015). High ecological integrity of the community and site fidelity as well as low tolerance ranges are inferred based on the clumped arrangement of the populations, number of populations and overall number of individuals.

Dispersal/Migration

Motility/Mobility

Adult: High (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (inferred from NatureServe, 2015)

Immigration/Emigration

Adult: Unlikely (inferred from NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Nonmigrant. Low dispersal and unlikely immigration are based on the clumped nature of the populations and the unique habitat requirements of this species (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decreasing (NatureServe, 2015)

Number of Populations:

1 - 5 (NatureServe, 2015)

Additional Population-level Information:

The boulder darter is currently known from approximately 104 river kilometers of the Elk River in Giles and Lincoln counties in Tennessee, and Limestone County in Alabama. The boulder darter continues to persist at low numbers within the Elk River and within the reintroduced Shoal Creek Nonessential Experimental Population. Recent Elk River observations (n=41 darters) have largely be limited to brood stock collections by Conservation Fisheries Inc. (CFI), and the population in the Elk River appears to be stable. The Service continues to work with the Tennessee Wildlife Resources Agency and CFI to facilitate captive propagation of boulder darter for reintroduction efforts into the Shoal Creek (tributary of the Tennessee River), where 14,124 individuals have been released since 2005. While the reintroduced population appears to be persisting in Shoal Creek, annual monitoring indicates low population resiliency relative to other similar darter species occupying similar stretches of river that are more commonly observed. Annual observations since the previous review (2017-2022) have varied between 0 and 1.78 observations per person hour (averaging 0.43 individuals per person hour since 2017) (USFWS, 2023).

Population Narrative:

Range and abundance have declined over the long term, but the degree of decline is uncertain. Decline of 30-50%. Total adult population size is unknown; habitat is difficult to sample. The species was known from about 75-80 specimens as of the early 2000s (Boschung and Mayden 2004). Aside from Richland Creek, boulder darters appear to be absent, or present in such low numbers as to be undetectable, in all Elk River tributaries (see USFWS 2009). In the early 1990s, the species occurred at only six sites in the Elk River main channel and three sites in two of its tributaries (Burkhead and Williams 1992). The species is still known from a relatively small number of sites (Boschung and Mayden 2004, USFWS 2009) and just a few locations (as defined by IUCN) (NatureServe, 2015). Low resiliency, redundancy and representation are inferred based on low numbers of known populations, restricted habitat range and low number of known individuals.

Threats and Stressors

Stressor: Toxic chemical spills (USFWS, 2009)
Exposure:
Response:
Consequence: Loss of individuals/loss of populations
Narrative: The boulder darter's limited geographic range and apparent small population size leaves the species extremely vulnerable to localized extinctions from accidental toxic chemical spills or other stochastic disturbances and to decreased fitness from reduced genetic diversity (USFWS, 2009).

Stressor: Siltation (USFWS, 2009)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Other threats to the boulder darter include physical habitat destruction resulting from a variety of human-induced impacts such as siltation, disturbance of riparian corridors, and changes in channel morphology. The most significant of these impacts is siltation caused by excessive releases of sediment from activities such as agriculture, resource extraction (e.g., coal mining, silviculture), road construction, and urban development (Waters 1995). Another possible contributor to sediment in the Elk River is bank sloughing due to hydropower peaking operations at Tims Ford Dam and the resultant wet-dry cycle on stream bank soils (USFWS, 2009).

Stressor: Improper pesticide use (USFWS, 2009)
Exposure:
Response:
Consequence: Loss of habitat/Loss of individuals
Narrative: Improper pesticide use is listed as a threat to this species (USFWS, 2009).

Stressor: Cold water release (USFWS, 2009)
Exposure:
Response:
Consequence: Loss of individuals
Narrative: Cold water releases from Tims Ford Reservoir remain threats to the boulder darter (USFWS, 2009).

Stressor: Gravel dredging (USFWS, 2009)
Exposure:
Response:
Consequence: Loss of habitat

Narrative: Gravel dredging is listed as a threat to this species (USFWS, 2009).

Stressor: Agricultural practices (USFWS, 2009)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Agricultural practices are listed as a threat to this species (USFWS, 2009).

Stressor: Disturbance of riparian corridors (USFWS, 2009)
Exposure:
Response:
Consequence: Loss of habitat
Narrative: Disturbance of riparian corridors is listed as a threat to this species (USFWS, 2009).

Stressor: Run-off (USFWS, 2009)
Exposure:
Response:
Consequence: Loss of habitat/loss of individuals
Narrative: Non-point source pollution from land surface runoff can originate from virtually any land use activity and may be correlated with impervious surfaces and storm water runoff. Pollutants may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streams such that the habitat and food sources for species like the boulder darter are negatively impacted. Construction and road maintenance activities associated with urban development typically involve earth-moving activities that increase sediment loads into nearby streams. Other siltation sources, including timber harvesting, clearing of riparian vegetation, and mining and agricultural practices, allow exposed earth to enter streams during or after precipitation events (USFWS, 2009).

Stressor: Inadequacy of existing regulations (USFWS, 2009)
Exposure:
Response:
Consequence: Loss of habitat/loss of individuals
Narrative: The boulder darter and its habitats are afforded limited protection from water quality degradation under the Clean Water Act of 1977 (33 U.S.C. 1251 et seq.) and the Tennessee Water Quality Control Act of 1977. These laws focus on point-source discharges, and many water quality problems are the result of non-point source discharges. Therefore, these laws and corresponding regulations have been inadequate to halt population declines and degradation of habitat for the boulder darter (USFWS, 2009).

Recovery

Reclassification Criteria:
Reclassification to threatened status would be considered when: 1. Through protection of the existing population in the Elk River and its tributaries and successful establishment of a reintroduced population in Shoal Creek or other historic habitat, or by discovery of an additional population, two distinct viable populations exist (USFWS, 2009).

2) Studies of the fish’s biological and ecological requirements have been completed, and the implementation of management strategies developed from these studies have been or are likely to be successful (USFWS, 2009).

Recovery Priority Number: 5 (USFWS, 2023)

Delisting Criteria:
Removal from the endangered species list would be considered when: 1) Through protection of the existing population and successful establishment of reintroduced populations or discovery of additional populations, three distinct viable populations exist. The existing Elk River population, including the two tributary segments, must be secure from river mile 90 downstream to river mile 30 (USFWS, 2009).

2) Studies of the fish’s biological and ecological requirements have been completed, and the implementation of management strategies developed from these studies has been successful (USFWS, 2009).

3) No foreseeable threats exist that would likely threaten survival of any of the populations (USFWS, 2009).

Recovery Actions:
- Reclassification and delisting criteria has not been met (USFWS, 2009).
- Delisting criteria has not been met (USFWS, 2009). Reclassification criteria has been partially met. In a laboratory study, Burkhead and Williams (1992) found that spawning habitat consists of boulders in flowing water with a velocity of about 1 to 2 feet (ft) (0.3 to 0.6 meters (m)) per second. Burkhead and Williams (1992) stated that nesting sites must have the following specific attributes: 1) the space must be between boulders, not between a boulder and gravel or a boulder and pieces of rubble, although a space created between a boulder and bedrock might be acceptable; 2) it must have a wedge-shaped configuration, with the two boulders touching at a relative narrow angle, creating a space into which the female wedges her eggs; 3) the site must have current flowing across it; 4) the cavity must be roughly horizontal (no vertical or nearly vertical spaces were selected); and 5) the boulders must not only be in the correct depth and current ranges, but they must also occur in a certain configuration relative to the current and to each other (USFWS, 2009).
- Delisting criteria has not been met (USFWS, 2009).
- Develop population monitoring techniques that will be effective in the Elk River. According to Rakes and Shute (2002), late summer and fall are the optimal times of year for conducting snorkel surveys, as agricultural impacts decrease and water clarity improves. Monitoring conditions, especially for snorkeling, are less than ideal in the Elk River due to fluctuations in flows from Tims Ford Dam. Initiate a long-term monitoring program in the Elk River and Shoal Creek to observe population levels/trends and habitat conditions of presently established populations as well as reintroduced and expanding populations (USFWS, 2009).
- Determine demographic viability of the boulder darter in the Elk River and assess the short-term feasibility of continued propagation and reintroduction efforts in the Shoal Creek NEP. Assess need for additional captive propagation and augmentation efforts in the Elk River. Review available population genetics data to determine whether they provide a sufficient basis for developing a broodstock management plan. Conduct additional genetics studies as

necessary (USFWS, 2009).

- Continue the adaptive management process of implementing operational changes at Tims Ford Reservoir that TVA initiated in 2008. Monitor progress of boulder darter dispersal upstream of Fayetteville with releases of warmer water temperatures from Tims Ford Dam (USFWS, 2009).
- Assess additional sites in the Elk River within the species' historic range to determine the availability and location of suitable augmentation sites for future recovery efforts (as needed). ? Determine feasibility of additional habitat improvement activities in the Elk River. In the mid- 1990s, the TWRA, Service, CFI, IP, and other partners attempted to augment spawning structures (i.e., man-made structures and natural slabrocks) in the Elk River. However, monitoring conducted after placement in the river, indicates that the slabrock and man-made structures were buried by sediments or washed downstream during flood events and no longer provided habitat for boulder darters (USFWS, 2009).
- Determine feasibility of additional habitat improvement activities in the Elk River. In the mid- 1990s, the TWRA, Service, CFI, IP, and other partners attempted to augment spawning structures (i.e., man-made structures and natural slabrocks) in the Elk River. However, monitoring conducted after placement in the river, indicates that the slabrock and man-made structures were buried by sediments or washed downstream during flood events and no longer provided habitat for boulder darters (USFWS, 2009).
- Continue to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat (USFWS, 2009).
- Continue efforts to reduce non-point pollution from agricultural activities by working through the Partners for Fish and Wildlife, USDA Farm Bill, and other landowner incentive programs to implement best management practices (USFWS, 2009).
- RECOMMENDATIONS FOR FUTURE ACTIONS - • Develop population monitoring techniques that will be effective in the Elk River. According to Rakes and Shute (2002), late summer and fall are the optimal times of year for conducting snorkel surveys, as agricultural impacts decrease and water clarity improves. Monitoring conditions, especially for snorkeling, are less than ideal in the Elk River due to fluctuations in flows from Tims Ford Dam. Initiate a long-term monitoring program in the Elk River and Shoal Creek to observe population levels/trends and habitat conditions of presently established populations as well as reintroduced and expanding populations. • Determine demographic viability of the boulder darter in the Elk River and assess the short-term feasibility of continued propagation and reintroduction efforts in the Shoal Creek NEP. Assess need for additional captive propagation and augmentation efforts in the Elk River. Review available population genetics data to determine whether they provide a sufficient basis for developing a broodstock management plan. Conduct additional genetics studies as necessary. • Continue the adaptive management process of implementing operational changes at Tims Ford Reservoir that TVA initiated in 2008. Monitor progress of boulder darter dispersal upstream of Fayetteville with releases of warmer water temperatures from Tims Ford Dam. ■ Assess additional sites in the Elk River within the species' historic range to determine the availability and location of suitable augmentation sites for future recovery efforts (as needed). • Determine feasibility of additional habitat improvement activities in the Elk River. In the mid- 1990s, the TWRA, Service, CFI, IP, and other partners attempted to augment spawning structures (i.e., man-made structures and natural slabrocks) in the Elk River. However, monitoring conducted after placement in the river, indicates that the

slabrock and man-made structures were buried by sedimen ts or washed downstream during flood events and no longer provided habitat for boulder darters. • Continue to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat. • Continue efforts to reduce non-point pollution from agricultural activities by working through the Partners for Fish and Wildlife, USDA Farm Bill, and other landowner incentive programs to implement best management practices (USFWS, 2017).

Conservation Measures and Best Management Practices:

- Recommended Future Activities Implement conservation actions recommended in the Boulder Darter Recovery Plan (Service 1989), the Tennessee Wildlife Action Plan (https://www.tn.gov/content/tn/twra/wildlife/actionplan.html), and Alabama Wildlife Action Plan (https://www.outdooralabama.com/research/statewildlife-grants) (USFWS, 2023).

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SPECIES ACCOUNT: *Eucyclogobius newberryi* (Tidewater goby)

Species Taxonomic and Listing Information

Listing Status: Endangered (Proposed for downlisted 3/13/13); 02/04/1994; California/Nevada Region (R8) (USFWS, 2016)

Physical Description

The tidewater goby (Eucyclogobius newberryi) is a small, elongate, grey-brown fish rarely exceeding 50 millimeters (mm) (2 inches [in.]) standard length (USFWS 2005). It is characterized by large pectoral fins and a ventral sucker-like disk formed by the complete fusion of the pelvic fins (59 FR 5494). Tidewater gobies have two dorsal fins set very close together or with a slightly confluent membrane. The first dorsal fin has five to seven slender spines, the second 11 to 13 soft, branched rays. The anal fin has 11 to 13 rays as well. The median fins are usually dusky, and the pectoral fin is transparent. Male tidewater gobies are nearly transparent, with a mottled brownish upper surface. Female tidewater gobies develop darker colors, often black, on the body and dorsal and anal fins. However, females' pectoral and pelvic fins, head, and tail remain grey or brown (USFWS 2005).

Taxonomy

The tidewater goby was first described as a new species (Gobius newberryi) by Girard (1856), from specimens collected in the San Francisco Bay Area (59 FR 5494). Based on these specimens, Gobius newberryi was reassigned in 1862 to the newly described genus Eucyclogobius (59 FR 5494). A member of the family Gobiidae, the tidewater goby is the only species in the genus Eucyclogobius, and is almost unique among fishes along the Pacific coast of the United States in its restriction to waters with low salinities in California's coastal wetlands (59 FR 5494). Its closest relatives are marine species, but the tidewater goby does not have a marine life history phase (59 FR 5494). One characteristic of tidewater gobies that distinguishes them from other California estuarine gobies is their small scales that are imbedded in the skin and are only visible with magnification (USFWS 2005). The best field marker for tidewater gobies is a transparent, whitish or yellow triangular area on the upper quarter to third of the first, spinous dorsal fin (USFWS 2005). The tidewater goby to the south of the gap between Los Angeles and Orange counties is probably a separate species from populations in the north, based on its divergent genetic makeup (78 FR 8746).

Historical Range

Tidewater gobies historically ranged from Tillas Slough (mouth of the Smith River, Del Norte County) near the Oregon border to Agua Hedionda Lagoon (San Diego County) (USFWS 2005).

Current Range

The northern limit of the species' range has not changed; however, the southern limit is now Cockleburr Canyon (northern San Diego County), 14.8 kilometers (km) (9.2 miles [mi.]) farther north from its historically known southern location (USFWS 2007). The known localities are discrete lagoons, estuaries, or stream mouths separated by mostly marine conditions (USFWS 2005).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 2/6/2013.

Legal Description

On February 6, 2013, the U.S. Fish and Wildlife Service, designated critical habitat for the tidewater goby (Eucyclogobius newberryi) under the Endangered Species Act of 1973, as amended (Act). In total, approximately 12,156 acres (4,920 hectares) in Del Norte, Humboldt, Mendocino, Sonoma, Marin, San Mateo, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, and San Diego Counties, California, fall within the boundaries of the critical habitat designation.

Critical Habitat Designation

The critical habitat designation for Eucyclogobius newberryi includes 65 units totaling 12,156 acres in Del Norte, Humboldt, Mendocino, Sonoma, Marin, San Mateo, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, and San Diego Counties, California.

DN–1: Tillas Slough. DN–1 consists of 21 ac (8 ha) of private lands. This unit is located in Del Norte County, approximately 3.0 mi (4.8 km) west of the community of Smith River and 8.0 mi (12.8 km) north of Lake Earl/Lake Tolowa (DN–2), which is also the next nearest extant subpopulation. DN–1 was occupied at the time of listing. This unit supports the northernmost tidewater goby subpopulation. DN–1 will support the recovery of the tidewater goby subpopulation within the North Coast Recovery Unit. This unit is important for maintaining the tidewater goby metapopulation in the region, and plays an important role in dispersal of the tidewater goby, which could prove vital if certain factors, such as climate change, adversely impact the tidewater goby habitat locally or to the south. A culvert that serves as a grade control structure, which mutes the tide cycle, provides relatively stable water levels in this unit (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

DN–2: Lake Earl/Lake Tolowa. DN–2 consists of 2,683 ac (1,086 ha). This unit is located in Del Norte County, approximately 3 mi (4.8 km) north of the town of Crescent City. The unit consists of 2,335 ac (945 ha) of State lands and 348 ac (140 ha) of private lands. This unit includes two contiguous lagoons (Lake Tolowa and Lake Earl), referred to collectively as Lake Earl. DN–2 is located 8.0 mi (12.8 km) south of (DN–1), which is also the nearest extant subpopulation. DN–2 was occupied at the time of listing. The tidewater goby subpopulation in DN–2 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the North Coast Recovery Unit. DN–2 is representative of extensive coastal lagoons and bays north of Cape Mendocino formed over uplifting Holocene sediments on broad flat coastal benches. These coastal benches include an intricate network of estuaries and other channels that are features essential to the conservation of the tidewater goby because they provide refugia during seasonal floods and breeding habitat through the full range of drought cycles. The water level and salinity within the lagoon varies seasonally and annually in response to: (a) Periods of high precipitation or drought within its watershed; (b) the timing, duration, and frequency of breaching events; (c) the water level in the lagoon at the time of breaching; and (d) ocean tidal cycles during and immediately following a breach. As a result of natural and human-induced environmental changes, including artificial breaching, maximum water depth within Lake Earl/Lake Tolowa varies during an annual cycle from less than 5 ft (1.5 m) deep to more than 10 ft (3 m) deep. The distribution of tidewater goby and the PCE within Lake Earl/Lake Tolowa changes in response to these dynamic short-term habitat conditions; over a multiyear cycle, tidewater goby may persist and breed anywhere within the lagoon. McCraney et al. (2010) indicate that artificial breaching activities may be reducing genetic diversity in this subpopulation by repeated bottlenecking. On an intermittent basis, DN–2 possesses a sandbar across the mouth of the lagoon or estuary during the majority of the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions during those times (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

HUM–1: Stone Lagoon. HUM–1 consists of 653 ac (264 ha). This unit is located in Humboldt County, approximately 11 mi (18 km) north of the City of Trinidad. The unit consists entirely of State lands. HUM– 1 is located 3.1 mi (5.0 km) north of Big Lagoon (HUM–2), which is also the nearest extant subpopulation. HUM–1 was occupied at the time of listing. The tidewater goby subpopulation in HUM–1 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the North Coast Recovery Unit. On an intermittent basis, HUM–1 possesses a sandbar across the mouth of the lagoon or estuary during the majority of the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

HUM–2: Big Lagoon. HUM–2 consists of 1,529 ac (619 ha). This unit is located in Humboldt County, approximately 7 mi (11 km) north of the City of Trinidad. The unit consists of 1,527 ac (618 ha) of State lands and 2 ac (1 ha) of private lands. HUM–2 is located 3.1 mi (5.0 km) south of Stone Lagoon (HUM–1), which is also the nearest extant subpopulation. HUM–2 was occupied at the time of listing. The tidewater goby subpopulation in HUM–2 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the North Coast Recovery Unit. Mark and recapture surveys for tidewater goby were conducted by Humboldt State University in a large cove near the State Park boat ramp in Big Lagoon during the fall of 2008, 2009, and 2010, to estimate the minimum tidewater goby subpopulation for each year (Hellmair 2011, p. 47). Results indicate that, in 2008, the tidewater goby subpopulation was approximately 21,000 individuals. In 2009, the subpopulation was approximately 1.7 to 3.4 million individuals in the cove. In 2010, the subpopulation was approximately 30,000 individuals in the same cove. Based on the results of this research, which estimated that the subpopulation fluctuated between 21,000 and 1.7–3.4 million individuals, and the relatively large size of the lagoon, Big Lagoon likely has the largest and most robust tidewater goby subpopulation in northern California. The results of the study also reflect how variable tidewater goby subpopulation numbers can be from year to year in a given location. On an intermittent basis, HUM–2 possesses a sandbar across the mouth of the lagoon or estuary during the majority of the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions during those times (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

HUM–3: Humboldt Bay. HUM–3 consists of 839 ac (339 ha). This unit is located in Humboldt County, within an approximate 8-mi (13-km) radius to the north, south, and west of the City of Eureka. The unit consists of 652 ac (264 ha) of Federal lands, 61 ac (24 ha) of State lands, 45 ac (18 ha) of local lands, and 81 ac (33 ha) of private lands. HUM–3 is located 18.4 mi (29.7 km) north of the Eel River (HUM–4), which is also the nearest extant subpopulation. HUM–3 was occupied at the time of listing. The tidewater goby subpopulation in HUM– 3 is likely a source population, which is important in maintaining the metapopulation dynamics, and hence the long-term viability, of the North Coast Recovery Unit. This subpopulation may provide essential demographic and genetic support to HUM–4, especially after periods of extreme floods, for example, after the 1964 ''Christmas Flood,'' when the subpopulation of tidewater goby at the Eel River estuary may have been extirpated. Humboldt Bay and its adjacent marshes and estuaries are a complex mixture of natural and human-made aquatic features that have experienced many decades of human-induced changes. These changes include the construction of levees, tidegates, culverts, and other water control structures, and extensive dredging of sandbars. Surrounding the Bay itself is a generally broad bench historically dominated by mudflats, tidal marshes, estuarine channels, and brackish marshes. Substantial portions of these habitats were converted to agricultural, urban, and industrial uses in recent history, resulting in the loss of as much as 10,000 ac (4,047 ha) of potentially suitable tidewater goby habitat. This critical habitat unit consists of a complex of interconnected estuary channels and tidegates along the eastern edge of Humboldt Bay, which collectively mimic, on a much-reduced scale, suitable habitat for tidewater goby. Many of these channels and marshes are themselves the result of changes to historical habitats, and depend on specific, yet generally undocumented, management activities, such as dredging or sandbar breaches, for their continued function. To address the dynamic variability of these habitats resulting from seasonal and inter-annual precipitation differences, the Service has included both the actual known locations where the tidewater goby has been documented, as well as portions of those channels contiguous to, and upchannel or downchannel from, occupied habitat. The Service has not designated Humboldt Bay proper as critical habitat, nor have we proposed major channels subject to substantial daily tidal fluctuations, as tidewater gobies are not known to breed there. Similarly, the Service has not designated channels that are discontiguous with occupied habitat, nor has the Service included intervening marsh or agricultural lands that may occasionally be flooded during severe winter storm events. Based on several recent surveys, we have found that the precise locations of tidewater goby use within the channel complex during any particular year may change in response to variations in precipitation and channel hydrology. The Service anticipates that the persistence of the tidewater goby source population within this unit may require protection of lagoons and estuaries that are not occupied every year, but collectively support a source population through an interconnected complex of channels and shallow water habitats. That is, any of the several known occupied locations within a channel complex may be used by tidewater goby during various years in response to dynamic habitat conditions during seasonal, annual, and longer term climatic cycles, such as drought. PCE 1c (a sandbar(s) across the mouth of a lagoon or estuary) is not likely to occur within this unit because a navigable, dredged channel with a permanent open connection to the ocean is maintained on a regular basis. PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

HUM–4: Eel River. This unit is located in Humboldt County, approximately 4.0 mi (6.5 ha) northwest of the City of Ferndale. The unit consists of two subunits, totaling 5 ac (2 ha) of State lands and 34 ac (13 ha) of private lands. Both subunits are outside the geographical area occupied by the species at the time of listing but are now occupied. The Eel River estuary is similar to Humboldt Bay (HUM–3) in that tidewater goby subpopulations have been found in isolated populations in severely and artificially fragmented habitats, which are often found behind tidegates, culverts, and other manmade structures. In Humboldt Bay (HUM–3), McCraney et al. (2010, p. 3315) found that artificial fragmentation reduced dispersal and gene flow in these subpopulations. The same may be true for the Eel River estuary subpopulations with isolated populations that are genetically distinct from each other. Therefore, until additional information is available regarding population genetics, distribution, and other parameters, the Service considers these two areas, the Eel River North Area (Subunit-4a) and the Eel River South Area (Subunit–4b), to be distinct from each other. Artificially fragmented habitats in the Eel River estuary may have genetically isolated or weakened populations of tidewater goby, as has been identified in Humboldt Bay (HUM–3) (McCraney et al. 2010, p. 3315). Current and proposed estuarine restoration projects in the Eel River estuary may improve dispersal of tidewater goby, increase genetic diversity, and aid in recovery of the species in these locations as well. Subunit-4a (Eel River North Area). Subunit-4a encompasses approximately 16 ac (6 ha), and consists of 5 ac (2 ha) of State lands and 11 ac (4 ha) of private lands. Subunit-4a is located 3.3 mi (5.3 km) north of Subunit-4b, which is also the nearest extant subpopulation. This subunit is essential for the conservation of the species because it possesses ecological characteristics that are important in maintaining the species' ability to adapt to changing environments, including the ability to disperse into higher channels and marsh habitat during severe flood events. The Eel River delta includes a large, complex estuary with a network of diked and natural slough channels with suitable tidewater goby habitat. The Eel River delta contains many small unsurveyed slough channels and other backwater areas that provide suitable habitat for tidewater goby, but it also contains larger channels open to direct tidal influence that do not provide suitable habitat and are not included in this subunit. This subunit consists of backwater channels and immediately adjacent marsh contiguous to the known-occupied habitat. This unit is subject to infrequent, yet severe, flooding from the nearby Eel River proper. The major flood event of 1964 (''Christmas Flood''), and other major floods during the past century, may have severely altered habitat in most channels, including those currently occupied. Tidewater goby may have survived the flood and resulting loss of habitat in the refugia provided in upper channels and swales. Alternatively, the species may have been extirpated at the Eel River delta during those severe events, and become reestablished through recolonization by individuals from Humboldt Bay populations (HUM–3). Of particular importance, the Eel River location is at the north end of one of the largest natural geographic gaps in the tidewater goby's geographic range. The gap extends to the Ten Mile River (Mendocino County) to the south, representing a coastline distance in excess of 135 mi (217 km). This unit is outside the geographical area occupied by the species at the time of listing, but is considered to be currently occupied. Although Subunit- 4a is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, Subunit-4a possesses a sandbar across the mouth of the lagoon or estuary during the majority of the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. Subunit-4b (Eel River South Area). Subunit-4b encompasses approximately 23 ac (9 ha), and consists entirely of private lands. Subunit-4b is located 3.3 mi (5.3 km) south of Subunit-4a, which is also the nearest extant subpopulation. This subunit is essential for the conservation of the species because it possesses ecological characteristics that are important in maintaining the species' ability to adapt to changing environments, including the ability to disperse into higher channels and marsh habitat during severe flood events. The Southern Eel River delta includes a large complex estuary with a network of diked and natural slough channels, and other backwater areas that provide suitable habitat for tidewater goby. It also contains larger channels open to direct tidal influence that do not provide suitable habitat and are not included in this unit. This unit consists of backwater channels and immediately adjacent marsh contiguous to the known-occupied habitat. This unit is subject to infrequent, yet severe, flooding from the nearby Eel River proper. The major flood event of 1964 (''Christmas Flood''), and other major floods during the past century, may have severely altered habitat in most channels, including those currently occupied. Tidewater goby may have survived the flood and resulting loss of habitat in the refugia provided in upper channels and swales. Alternatively, the species may have been extirpated at the Eel River delta during those severe events, and become reestablished through recolonization by individuals from Humboldt Bay populations (HUM–3). Of particular importance, the Eel River location is at the north end of one of the largest natural geographic gaps in the tidewater goby's geographic range. The gap extends to the Ten Mile River (Mendocino County) to the south, representing a coastline distance in excess of 135 mi (217 km). This unit is outside the geographical area occupied by the species at the time of listing, but is considered to be currently occupied. Although Subunit- 4b was outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, Subunit-4b possesses a sandbar across the mouth of the lagoon or estuary during the majority of the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

MEN–1: Ten Mile River. MEN–1 consists of 73 ac (30 ha). This unit is located in Mendocino County, approximately 9.0 mi (14.5 km) north of the Town of Fort Bragg. The unit consists of 17 ac (7 ha) of State lands and 56 ac (23 ha) of private lands. MEN–1 is located 5.6 mi (8.9 km) north of the Virgin Creek (MEN–2), which is also the nearest extant subpopulation. MEN–1 was occupied by tidewater goby at the time of listing. The tidewater goby subpopulation in MEN–1 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the North Coast Recovery Unit. Furthermore, this unit is the largest block of habitat along the coast of Mendocino County, and is the first location on the southern end of one of the longest stretches of unsuitable habitat in the species' range (previously described under HUM–4). Thus, this unit is important to connect subpopulations within Mendocino County. South of Ten Mile River, only three other small isolated locations (MEN–2, 3, 4) occupied by the tidewater goby are known to exist across the more than 100 miles of rugged coastline between MEN–1 and SON–1 in south coastal Sonoma County. On an intermittent basis, MEN–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

MEN–2: Virgin Creek. MEN–2 consists of 4 ac (2 ha). This unit is located in Mendocino County, approximately 3.5 mi (5.6 km) north of the Town of Fort Bragg. The unit consists of 2 ac (1 ha) of State lands and 2 ac (1 ha) of private lands. MEN–2 is located 1.2 mi (2.0 km) north of Pudding Creek (MEN–3), which is also the nearest extant subpopulation. MEN–2 was occupied by tidewater goby at the time of listing. The tidewater goby subpopulation in MEN–2 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the North Coast Recovery Unit. On an intermittent basis, MEN–2 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

MEN–3: Pudding Creek. MEN–3 consists of 17 ac (7 ha). This unit is located in Mendocino County, approximately 2.5 mi (4.0 km) north of the town of Fort Bragg. The unit consists of 10 ac (4 ha) of State lands, 1 ac (less than 1 ha) of local lands, and 6 ac (2 ha) of private lands. MEN–3 is located 1.2 mi (2.0 km) south of Virgin Creek (MEN–2), which is also the nearest extant subpopulation. MEN–3 was occupied by the tidewater goby at the time of listing. This unit allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within the North Recovery Unit. On an intermittent basis, MEN–3 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

MEN–4: Davis Lake and Manchester State Park Ponds. MEN–4 consists of 29 ac (12 ha). This unit is located in Mendocino County, approximately 1.2 mi (1.9 ha) west of the community of Manchester. The unit consists entirely of State lands. MEN–4 is located 32.4 mi (52.2 km) south of Pudding Creek (MEN–3), which is also the nearest extant subpopulation. MEN–4 was occupied by tidewater goby at the time of listing. The tidewater goby subpopulation in MEN–4 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the North Coast Recovery Unit. On an intermittent basis, MEN–4 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SON–1: Salmon Creek. SON–1 consists of 108 ac (44 ha). This unit is located in Sonoma County, approximately 7 mi (11.3 km) south of the community of Jenner. The unit consists of 47 ac (19 ha) of State lands, 14 ac (6 ha) local lands, and 47 ac (19 ha) of private lands. SON–1 is located 5.3 mi (8.5 km) north of the Estero Americano unit (MAR–1), which is also the nearest extant subpopulation. SON–1 was occupied by tidewater goby at the time of listing. The geological feature known as Bodega Head separates Salmon Creek and Estero Americano, and could reduce the exchange of tidewater goby between these two locations. The tidewater goby population in this unit is likely a source population, and is therefore important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby subpopulation that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). Maintaining this unit will reduce the chance of losing the tidewater goby within the Greater Bay Area Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, SON–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

MAR–1: Estero Americano. MAR–1 consists of 465 ac (188 ha). This unit is located in Marin County, approximately 3.5 mi (5.7 km) south of Bodega Bay. The unit consists entirely of private lands. MAR–1 is located 2.2 mi (3.5 km) north of the Estero de San Antonio (MAR–2), which is also the nearest extant subpopulation. MAR–1 was occupied by tidewater goby at the time of listing. The tidewater goby subpopulation in MAR–1 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the Greater Bay Area Recovery Unit. On an intermittent basis, MAR–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

MAR–2: Estero de San Antonio. MAR–2 consists of 285 ac (115 ha). This unit is located in Marin County, approximately 5.6 mi (9 km) south of Bodega Bay. The unit consists entirely of private lands. MAR–2 is located 2.2 mi (3.5 km) south of the Estero Americano (MAR–1), which is also the nearest extant subpopulation. MAR–2 was occupied by tidewater goby at the time of listing. This critical habitat unit supports a source population of tidewater goby that likely provides individuals that are recruited into surrounding subpopulations. Given the close proximity of the MAR–1 and MAR–2 units and the dispersal capabilities of tidewater goby, it is likely that the two subpopulations have exchanged individuals in the past and will continue to exchange individuals in the future. Exchange between these subpopulations would bolster the continued sustainable existence of the two subpopulations, which would, together with unit SON–1, provide for natural colonization of available, but is considered to be currently unoccupied, estuaries within the region south of the Russian River and north of Point Reyes. This critical habitat unit provides habitat for a tidewater goby population that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p.

1172). Maintaining this unit will reduce the chance of losing the tidewater goby within the Greater Bay Area Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, MAR–2 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

MAR–3: Walker Creek. MAR–3 consists of 118 ac (48 ha). This unit is located in Marin County, approximately 2.5 mi (4 km) southwest of the Town of Tomales. The unit consists of 9 ac (4 ha) of State lands and 109 ac (44 ha) of private lands. MAR– 3 is located 4.6 mi (7.4 km) southeast of the Estero de San Antonio unit (MAR– 2), which is also the nearest extant subpopulation. This unit is outside the geographical area occupied by the species at the time of listing and is not considered to be currently occupied. However, tidewater gobies were collected at Walker Creek in 1897, but were not found in sampling efforts conducted in 1996 or 1999 (Service 2005a, p. C–8). This unit is identified in the Recovery Plan as a potential reintroduction site, and could provide habitat for maintaining the tidewater goby metapopulation in the region. MAR–3 is essential for the conservation of the species because establishing a tidewater goby population in this unit will support the recovery of the tidewater goby population within the Greater Bay Area Recovery Unit and help facilitate additional colonization of currently unoccupied locations. Although MAR–3 is outside the geographical area occupied at the time of listing and is not currently occupied, it does possess the PCE that is needed to support tidewater goby. PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

MAR–4: Lagunitas (Papermill) Creek. MAR–4 consists of 998 ac (405 ha). This unit is located in Marin County, approximately 20.5 mi (33 km) south of Bodega Bay. The unit consists of 318 ac (129 ha) of Federal lands, 459 ac (186 ha) of State lands, and 221 ac (90 ha) of private lands. MAR–4 is located 15.5 mi (25.0 km) south of the Estero de San Antonio unit (MAR–2), which is also the nearest extant subpopulation. Records indicate tidewater goby occurred at this location historically. This unit is outside the geographical area occupied by the species at the time of listing, but recent surveys have confirmed that the unit is currently occupied. This unit is essential for the conservation of the species because it is the only known location of the tidewater goby to remain within the greater Tomales Bay area. Without this subpopulation, there would be no source population within dispersal distance of Tomales Bay to maintain the metapopulation dynamics of subpopulations within the area. Tomales Bay is designated as ‘‘wetlands of significant importance’’ under the International Convention on Wetlands (http://sanctuarysimon.org/farallones/ sections/estuaries/overview.php). Although MAR–4 is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. We do not have information that confirms that PCE 1c (a sandbar(s) across the mouth of the lagoon or estuary) is present within this unit on at least an intermittent basis. However, PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

MAR–5: Bolinas Lagoon. MAR–5 consists of 1,114 ac (451 ha). This unit is located in Marin County, approximately 0.5 mi (0.81 km) east of the community of Bolinas. The unit consists of 29 ac (12 ha) of Federal Lands, 1,048 ac (424 ha) of local lands, and 37 ac (15 ha) of private lands. MAR–5 is located 9.4 mi (15.1 km) northwest of the Rodeo Lagoon unit (MAR–6), which is also the nearest extant subpopulation. This unit is outside the geographical area occupied by the species at the time of listing and is not known to be currently occupied, and there are no historical tidewater goby records for this location. However, this unit is essential for the conservation of the species because it provides suitable habitat within potential dispersal distance of nearby occupied units, is identified in the Recovery Plan as a potential introduction site, and could help maintain tidewater goby metapopulations in the region. Bolinas Lagoon is designated as ‘‘wetlands of significant importance’’ under the International Convention on Wetlands (http://sanctuarysimon.org/farallones/ sections/estuaries/overview.php).If a tidewater goby subpopulation is established in this unit, MAR–5 unit will support the recovery of the tidewater goby population within the Greater Bay Recovery Unit and help facilitate colonization of currently unoccupied locations. Although MAR–5 is outside the geographical area occupied at the time of listing and is not currently occupied, it does possess the PCE that is needed to support tidewater goby. The Service does not have information that confirms that PCE 1c (a sandbar(s) across the mouth of the lagoon or estuary) is present within this unit on at least an intermittent basis. However, PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

MAR–6: Rodeo Lagoon. MAR–6 consists of 40 ac (16 ha). This unit is located in Marin County, approximately 3.8 mi (6 km) north of San Francisco. The unit consists entirely of Federal lands. MAR–6 is located 9.4 mi (15.1 km) south of Bolinas Lagoon (MAR–5), and is separated from the nearest extant subpopulation to the south, San Gregorio Creek (SM–1), by 36 mi (58 km). MAR–6 was occupied by tidewater goby at the time of listing. MAR–6 is the only known location where the tidewater goby remains within the greater San Francisco Bay Area. This critical habitat unit provides habitat for a tidewater goby subpopulation that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). It also provides habitat for a subpopulation of tidewater goby that could disperse to other adjoining habitats. Maintaining this unit will reduce the chance of losing the tidewater goby in the Greater Bay Recovery Unit and help conserve genetic diversity within the species. On an intermittent basis, MAR–6 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SM–1: San Gregorio Creek. SM–1 consists of 45 ac (18 ha). This unit is located in San Mateo County, approximately 28 mi (45 km) south of the San Francisco–San Mateo County line. The unit consists of 33 ac (13 ha) of State lands and 12 ac (5 ha) of private lands. SM–1 is located 1.5 mi (2.4 km) north of Pomponio Creek (SM–2), and is separated from the nearest extant subpopulation to the south, Pescadero– Butano Creek (SM–3), by 3.8 mi (6.1 km). SM–1 was occupied by tidewater goby at the time of listing. The tidewater goby subpopulation in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics.

This critical habitat unit provides habitat for a tidewater goby subpopulation that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). This unit is noted for high densities of tidewater goby (Swenson 1993, p. 3). On an intermittent basis, SM–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SM–2: Pomponio Creek. SM–2 consists of 7 ac (3 ha). This unit is located in San Mateo County, approximately 3.5 mi (5.6 km) north of the community of Pescadero. The unit consists of 1 ac (less than 1 ha) of State lands and 6 ac (2 ha) of private lands. SM–2 is located 1.5 mi (2.4 km) south of the San Gregorio Creek unit (SM–1), which is also the nearest extant subpopulation. This unit is outside the geographical area occupied by the species at the time of listing, but is considered to be currently occupied. This unit is essential for the conservation of the species because it provides habitat for the species, allows for connectivity between tidewater goby source populations from nearby units, supports gene flow, and provides for metapopulation dynamics in the region. Although SM–2 is outside the geographical area occupied at the time of listing, it does possess the PCE that supports tidewater goby. On an intermittent basis, SM–2 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SM–3: Pescadero–Butano Creek. SM–3 consists of 245 ac (99 ha). This unit is located in San Mateo County, approximately 32.0 mi (51.0 km) south of the San Francisco–San Mateo County line. This unit consists of 241 ac (97 ha) of State lands and 4 ac (2 ha) of private lands. SM–3 is located 2.2 mi (3.5 km) south of Pomponio Creek (SM–2), and is separated from the nearest extant subpopulation to the south, in Bean Hollow Creek (SM–4), by 3.0 mi (4.8 km). SM–3 was occupied by tidewater goby at the time of listing. This unit allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within the Greater Bay Area Recovery Unit. On an intermittent basis, SM–3 possesses a sandbar across the mouth of the lagoon or estuary during the late spring and early fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SM–4: Bean Hollow Creek (Arroyo de Los Frijoles). SM–4 consists of 10 ac (4 ha). This unit is located in San Mateo County, approximately 34.8 mi (56.0 km) south of the San Francisco–San Mateo County line. The unit consists of 3 ac (1 ha) of State lands and 7 ac (3 ha) of private lands. SM–4 is located approximately 3.0 mi (4.8 km) south of the Pescadero– Butano Creek (SM–3), which is also the nearest extant subpopulation. SM–4 was occupied by tidewater goby at the time of listing. Maintaining this unit, together with the two units to the north, will reduce the chance of losing the tidewater goby along this important coastal range and allow for connectivity between tidewater goby source populations, thereby supporting gene flow and metapopulation dynamics within the Greater Bay Recovery Unit. On an intermittent basis, SM–4 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SC–1: Waddell Creek. SC–1 consists of 75 ac (30 ha). This unit is located in Santa Cruz County, approximately 18 mi (29 km) northwest of the city of Santa Cruz. The unit consists of 39 ac (16 ha) of State lands and 36 ac (14 ha) of private lands. SC– 1 is located approximately 5.0 mi (8.0 km) north of the Scott Creek (SC–2), which is also the nearest extant subpopulation. This unit is at the northern extent of this metapopulation as described in the Recovery Plan. Tidewater gobies were present in low numbers in 1991 through 1996, but were not detected during surveys from 1997 to 2000 (Service 2005a, p. C–12). Tidewater gobies were again detected during surveys in August 2012 (Rischbieter, in litt. 2012). SC–1 was occupied by tidewater goby at the time of listing. This unit provides habitat for tidewater gobies dispersing from Scott Creek (SC–2), which may serve to decrease the risk of extirpation of this metapopulation through stochastic events. This unit allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within the Greater Bay Area Recovery Unit. On an intermittent basis, SC–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SC–2: Scott Creek. SC–2 consists of 74 ac (30 ha). This unit is located in Santa Cruz County, approximately 11.8 mi (19.0 km) northwest of the City of Santa Cruz. The unit consists of 66 ac (27 ha) of State lands, 6 ac (2 ha) of local lands, and 2 ac (1 ha) of private lands. SC–2 is located 5.0 mi (8.0 km) south of Waddell Creek (SC–1), and is separated from the nearest extant subpopulation to the south, in Laguna Creek (SC–3), by 6.0 mi (9.6 km). SC–2 is outside the geographical area occupied by the species at the time of listing, but is considered to be currently occupied. This unit is essential for the conservation of the species because it provides habitat for the species, allows for connectivity between tidewater goby source populations from nearby units, supports gene flow, and provides for metapopulation dynamics within the Greater Bay Area Recovery Unit. Although SC–2 is outside the geographical area occupied at the time of listing, it does possess the PCE that supports tidewater goby. On an intermittent basis, SC–2 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SC–3: Laguna Creek. SC–3 consists of 26 ac (11 ha). This unit is located in Santa Cruz County, approximately 7.5 mi (12.0 km) west of the City of Santa Cruz. The unit consists entirely of State lands. SC–3 is located 6.0 mi (9.6 km) south of Scott Creek (SC–2), the nearest extant population to the north, and is separated from the nearest extant subpopulation to the south, in Baldwin Creek (SC–4), by 2.0 mi (3.2 km). SC–3 was occupied by tidewater goby at the time of listing. The tidewater goby subpopulation in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby population that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). Together with Baldwin Creek (SC–4) to the south, this unit helps conserve the genetic diversity of the species. On an intermittent basis, SC–3 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SC–4: Baldwin Creek. SC–4 consists of 27 ac (11 ha). This unit is located in Santa Cruz County, approximately 6 mi (9.7 km) west of the City of Santa Cruz. The unit consists entirely of State lands. SC–4 is located 2.0 mi (3.2 km) south of Laguna Creek (SC–3), and is separated from the nearest extant subpopulation to the south, Lombardi Creek (not designated as critical habitat), by 0.7 mi (1.2 km). SC–4 was occupied by tidewater goby at the time of listing. The tidewater goby population in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby population that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172) and, together with Laguna Creek (SC–3) to the north, helps conserve genetic diversity within the species. On an intermittent basis, SC–4 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SC–5: Moore Creek. SC–5 consists of 15 ac (6 ha). This unit is located in Santa Cruz County, approximately 2.0 mi (3.2 km) west of the City of Santa Cruz. The unit consists entirely of Federal lands. SC–5 is located 4.0 mi (6.4) south of Baldwin Creek. SC–5 is separated from the nearest extant subpopulation to the north, Younger Lagoon (not designated as critical habitat), by 0.5 mi (0.8 km). SC–5 was occupied by tidewater goby at the time of listing. Maintaining this unit will reduce the chance of losing the tidewater goby within the Greater Bay Area Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, SC–5 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SC–6: Corcoran Lagoon. SC–6 consists of 28 ac (11 ha). This unit is located in Santa Cruz County, approximately 3 mi (4.8 km) east of the City of Santa Cruz. This unit consists of 1 ac (less than 1 ha) of State lands, 6 ac (2 ha) of local lands, and 21 ac (8 ha) of private lands. SC–6 is located 4.0 mi (6.4 km) south of Moore Creek (SC–5), and the unit is separated from the nearest extant subpopulation to the south, in Moran Lake (not designated as critical habitat), by 0.7 mi (1.1 km). SC–6 was occupied by tidewater goby at the time of listing. The tidewater goby subpopulation in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby population that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). Maintaining this unit will reduce the chance of losing the tidewater goby within the Greater Bay Area Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, SC–6 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SC–7: Aptos Creek. SC–7 consists of 9 ac (4 ha). This unit is located in Santa Cruz County, approximately 0.5 mi (0.8 km) southwest of the City of Aptos. The unit consists entirely of State lands. SC–7 is located 4.1 mi (6.6 km) east of Corcoran Lagoon (SC–6), and is separated from the nearest extant subpopulation to the north, Moran Lake (not designated as critical habitat), by 4.2 mi (6.75 km). SC–7 was occupied by tidewater goby at the time of listing. The tidewater goby population in SC–7 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the Greater Bay Area Recovery Unit. On an intermittent basis, SC–7 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SC–8: Pajaro River. SC–8 consists of 215 ac (87 ha). This unit is located in Santa Cruz County, approximately 5 mi (8 km) southwest of the City of Watsonville. The unit consists of 158 ac (64 ha) of State lands, 11 ac (4 ha) of local lands, and 46 ac (19 ha) of private lands. SC–8 is located 9.7 mi (15.6 km) south of Aptos Creek (SC– 7), and is separated from the nearest extant subpopulation to the south, in Bennett Slough (MN–1), by 3.0 mi (4.7 km). SC–8 was occupied by tidewater goby at the time of listing. Maintaining this unit will reduce the chance of losing the tidewater goby within the Greater Bay Area Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, SC–8 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

MN–1: Bennett Slough. MN–1 consists of 167 ac (68 ha). This unit is located in Monterey County, approximately 3.7 mi (6 km) northwest of the Town of Castroville. This unit consists of 108 ac (44 ha) of State lands, 5 ac (2 ha) of local lands, and 54 ac (22 ha) of private lands. MN–1 is located 4.1 mi (6.6 km) south of the Pajaro River (SC–8), and is separated from the nearest extant subpopulation to the south, Moro Cojo Slough (not designated as critical habitat), by 1.3 mi (2.1 km). MN–1 was occupied by tidewater goby at the time of listing. The tidewater goby population in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby population that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172), and maintaining it will reduce the chance of losing the tidewater goby within the Greater Bay Area Recovery Unit, and help conserve genetic diversity within the species. PCE 1c (a sandbar(s) across the mouth of lagoon or estuary) is not likely to occur within this unit because it has a navigable, dredged channel with a permanent open connection to the ocean that is maintained on a regular basis. However, PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

MN–2: Salinas River. MN–2 consists of 466 ac (189 ha). This unit is located in Monterey County, approximately 7.5 mi (12 km) north of the City of Seaside. The unit consists of 195 ac (79 ha) of Federal lands, 33 ac (13 ha) of State lands, 1 ac (less than 1 ha) of local lands, and 237 ac (96 ha) of private lands. Unit MN–2 is located 4.0 mi (8.0 km) south of the Bennett Slough unit (MN–1). This unit is outside the geographical area occupied by the species at the time of listing and is not considered to be currently occupied; however, this unit is essential for the conservation of the species. Tidewater gobies were last collected here in 1951, but were not present during surveys in 1991, 1992, and 2004 (Service 2005a, p. C–16). This unit is identified in the Recovery Plan as a potential reintroduction site. This unit would provide habitat for tidewater goby that disperse from Bennett Slough and Moro Cojo Slough, either through natural means or by reintroduction, which may serve to decrease the risk of extirpation of this metapopulation through stochastic events. This unit will also allow for connectivity between tidewater goby source populations, and thereby support gene flow and metapopulation dynamics within the Greater Bay Area Recovery Unit. Lastly, this unit is one of only three locations in Monterey County that have harbored tidewater goby and is one of the two subpopulations in the metapopulation as described in the Recovery Plan. Therefore, this unit is especially important for ensuring the viability of the metapopulation. Although MN–2 is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, MN–2 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SLO–1: Arroyo de la Cruz. SLO–1 consists of 33 ac (13 ha). This unit is located in San Luis Obispo County, approximately 8.0 mi (13.0 km) northwest of San Simeon. The unit consists of 25 ac (10 ha) of State lands and 8 ac (3 ha) of private lands. SLO– 1 is located approximately 2.0 mi (3.2 km) north of the Arroyo de Corral unit (SLO–2), which is also the nearest extant subpopulation. This unit is outside the geographical area occupied by the species at the time of listing and is not known to be currently occupied, and there are no historical tidewater goby records for this location. However, this unit is essential for the conservation of the species because it provides habitat to nearby units and is identified in the Recovery Plan as a potential introduction site, and could provide habitat for maintaining the tidewater goby metapopulation in the region. This unit will provide habitat for tidewater goby that disperse from Arroyo del Corral through introduction of the species, which may serve to decrease the risk of extirpation of this metapopulation through stochastic events. This unit is one of two locations with suitable habitat within the Central Coast Recovery Subunit (CC 1), as described in the Recovery Plan. Therefore, this unit is especially important for ensuring the viability of the metapopulation because if the subpopulation within the Arroyo de Corral unit (SLO–2) is extirpated, the entire metapopulation would be lost. Although SLO–1 is outside the geographical area occupied at the time of listing and is not currently occupied, it does possess the PCE that is needed to support tidewater goby. SLO–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SLO–2: Arroyo del Corral. SLO–2 consists of 5 ac (3 ha). This unit is located in San Luis Obispo County, approximately 6 mi (9.7 km) northwest of San Simeon. The unit consists of 4 ac (2 ha) of State lands and 1 ac (less than 1 ha) of private lands. SLO–2 is located 2 mi (3.2 km) south of Arroyo de la Cruz (SLO–1) and is separated from the nearest extant subpopulation to the south, Oak Knoll Creek (SLO–3), by 4.3 mi (6.9 km). SLO–2 was occupied at the time of listing. The tidewater goby subpopulation in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby subpopulation that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). Maintaining this unit will reduce the chance of losing the tidewater goby within the Central Coast Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, SLO–2 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SLO–3: Oak Knoll Creek (Arroyo Laguna). SLO–3 consists of 5 ac (3 ha). This unit is located in San Luis Obispo County, approximately 2 mi (3.2 km) northwest of San Simeon. The unit consists of 4 ac (2 ha) of State lands and 1 ac (less than 1 ha) of private lands. SLO–3 is located 4.3 mi (6.9 km) south of Arroyo del Corral (SLO–2) and is separated from the nearest extant subpopulation to the south, in Arroyo de Tortuga (not designated as critical habitat), by 0.5 mi (0.8 km). SLO–3 was occupied at the time of listing. This unit allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within the Central Coast Recovery Unit. On an intermittent basis, SLO–3 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SLO–4: Little Pico Creek. SLO–4 consists of 9 ac (4 ha). This unit is located in San Luis Obispo County, approximately 6.7 mi (10.8 km) northwest of the Town of Cambria. The unit consists of 2 ac (1 ha) of State lands and 7 ac (3 ha) of private lands. SLO– 4 is located 3.7 mi (5.9 km) south of Oak Knoll Creek (SLO–3). The unit is separated from the nearest extant subpopulation to the north, in Broken Bridge Creek (not designated as critical habitat), by 1.4 mi (2.2 km). SLO–4 was occupied at the time of listing. The tidewater goby subpopulation in SLO–4 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the Central Coast Recovery Unit. On an intermittent basis, SLO–4 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SLO–5: San Simeon Creek. SLO–5 consists of 17 ac (7 ha). This unit is located in San Luis Obispo County, approximately 3.3 mi (5.3 km) northwest of the Town of Cambria. The unit consists entirely of State lands. SLO–5 is located 3.8 mi (6.1 km) south of Little Pico Creek (SLO–4), and is separated from the nearest extant subpopulation to the south, in Santa Rosa Creek (not designated as critical habitat), by 2.6 mi (4.2 km). SLO–5 was occupied at the time of listing. The tidewater goby subpopulation in SLO–5 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the Central Coast Recovery Unit. On an intermittent basis, SLO–5 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SLO–6: Villa Creek. SLO–6 consists of 15 ac (7 ha). This unit is located in San Luis Obispo County, approximately 9.6 mi (15.4 km) southeast of Cambria. The unit consists of 14 ac (6 ha) of State lands and 1 ac (less than 1 ha) of private lands. SLO– 6 is located 12.3 mi (19.8 km) south of San Simeon Creek (SLO–5), and is separated from the nearest extant subpopulation to the south, in San Geronimo Creek (SLO–7), by 2.3 mi (3.7 km). SLO–6 was occupied at the time of listing. The tidewater goby subpopulation in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby subpopulation that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). Maintaining this unit will reduce the chance of losing the tidewater goby within the Central Coast Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, SLO–6 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SLO–7: San Geronimo Creek. SLO–7 consists of 1 ac (less than 1 ha). This unit is located in San Luis Obispo County, approximately 7.6 mi (12.2 km) northwest of the Town of Morro Bay, and approximately 1.4 mi (2.5 km) west of the Town of Cayucos. The unit consists entirely of State lands. SLO–7 is located 2.3 mi (3.7 km) south of Villa Creek (SLO–6), and is separated from the nearest extant subpopulation to the south, in Cayucos Creek (not designated as critical habitat), by 1.5 mi (2.4 km). SLO–7 was occupied at the time of listing. The tidewater goby subpopulation in SLO–7 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the Central Coast Recovery Unit. On an intermittent basis, SLO–7 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SLO–8: Toro Creek. SLO–8 consists of 9 ac (4 ha). This unit is located in San Luis Obispo County, approximately 2.3 mi (3.7 km) south of the Town of Cayucos. The unit consists of 1 ac (less than 1 ha) of State lands and 8 ac (3 ha) of private lands. SLO–8 is located 5 mi (8.0 km) south of San Geronimo Creek (SLO–7), and is separated from the nearest extant subpopulation to the north, in Old Creek (not designated as critical habitat), by 1.8 mi (2.9 km). SLO–8 was occupied at the time of listing. Maintaining this unit will reduce the chance of losing the tidewater goby within the Central Coast Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, SLO–8 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SLO–9: Los Osos Creek. SLO–9 consists of 73 ac (30 ha). This unit is located in San Luis Obispo County, within the Town of Baywood. The unit consists of 62 ac (25 ha) of State lands, 1 ac (less than 1 ha) of local lands, and 10 ac (4 ha) of private lands. The unit is separated from the nearest extant subpopulation to the north, in Toro Creek (SLO–8), by 8.0 mi (12.8 km). Tidewater gobies were present during surveys in 2001 (Service 2005a, p. C–21). Prior to the observations in 2001, tidewater goby had not been seen here since 1981 (Service 2005a, p. C– 21). Therefore, SLO–9 is outside the geographical area occupied by the species at the time of listing but is currently occupied. This unit is essential for the conservation of the species because it provides habitat to nearby units and is identified in the Recovery Plan as a potential introduction site, and could provide habitat for maintaining the tidewater goby metapopulation in the region. Maintaining this unit will also reduce the chance of losing the tidewater goby within the Central Coast Recovery Unit. Although SLO–9 is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. PCE 1c (a sandbar(s) across the mouth of lagoon or estuary) is not likely to occur within this unit because it has a navigable channel with an open connection to Morro Bay, which is dredged on a regular basis. However, PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SLO–10: San Luis Obispo Creek. SLO–10 consists of 31 ac (12 ha). This unit is located in San Luis Obispo County, within the Town of Avila Beach. The unit consists of 3 ac (1 ha) of local lands, and 28 ac (11 ha) of private lands. The unit is separated from the nearest extant subpopulation to the south, in Pismo Creek (SLO–11), by 7.0 mi (11.2 km). SLO–10 was occupied at the time of listing. The tidewater goby subpopulation in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby subpopulation that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). On an intermittent basis, SLO–10 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SLO–11: Pismo Creek. SLO–11 consists of 20 ac (9 ha). This unit is located in San Luis Obispo County, within the Town of Pismo Beach. The unit consists of 14 ac (6 ha) of State lands, 1 ac (less than 1 ha) of local lands, and 5 ac (2 ha) of private lands. SLO–11 is located 7 mi (11.2 km) south of San Luis Obispo Creek (SLO– 10). The unit is separated from the nearest extant subpopulation to the south, in Arroyo Grande Creek (not designated as critical habitat), by 2.6 mi (4.2 km). SLO–11 was occupied at the time of listing. The tidewater goby subpopulation in SLO–11 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the Conception Recovery Unit. On an intermittent basis, SLO–11 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SLO–12: Oso Flaco Lake. SLO–12 consists of 171 ac (69 ha). This unit is located in San Luis Obispo County, approximately 5 mi (8.0 km) northwest of the City of Santa Maria. The unit consists of 165 ac (67 ha) of State lands and 6 ac (2 ha) of private lands. The unit is separated from the nearest extant subpopulation to the south, the Santa Maria River (SB–1), by 4 mi (6.4 km). This unit is outside the geographical area occupied by the species at the time of listing and is not known to be currently occupied, and there are no historical tidewater goby records for this location. However, this unit is essential for the conservation of the species because it provides habitat to nearby units and is identified in the Recovery Plan as a potential introduction site, and could provide habitat for maintaining the tidewater goby metapopulation in the region. This unit will provide habitat for tidewater goby that disperse from Arroyo Grande Creek and the Santa Maria River, either through natural means or by introduction, which may serve to decrease the risk of extirpation of this metapopulation through stochastic events. This unit would also allow for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics in this region. Although tidewater goby may be presently precluded from this location due to water quality impairments, the California Regional Water Control Board is currently working with the Service to remedy these impairments. Therefore, we anticipate the habitat at this location will be suitable for tidewater goby in the future and have determined that this unit is essential for the conservation of the species as described above. Although SLO–12 is outside the geographical area occupied at the time of listing and is not currently occupied, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, SLO–12 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SB–1: Santa Maria River. SB–1 consists of 474 ac (192 ha). This unit is located in Santa Barbara County, approximately 13 mi (21 km) west of the City of Santa Maria. The unit consists of 42 ac (17 ha) of local lands and 432 ac (175 ha) of private lands. SB–1 is located 4 mi (6.4 km) south of Oso Flaco Lake (SLO–12), and is separated from the nearest extant subpopulation to the south, in Shuman Canyon (not designated as critical habitat; see Application of Section 4(a)(3) of the Act—Vandenberg Air Force Base section below), by 8.6 mi (13.9 km). SB–1 was occupied at the time of listing. The tidewater goby subpopulation in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby subpopulation that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). Maintaining this unit will reduce the chance of losing the tidewater goby within the Conception Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, SB–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SB–2: Canada de las Agujas. SB–2 consists of 1 ac (less than 1 ha). This unit is located in Santa Barbara County, approximately 7.2 mi (11.6 km) west of Gaviota. The unit consists entirely of private lands. SB–2 is located 38.8 mi (62.5 km) south of the Santa Maria River (SB–1), and is separated from the nearest extant subpopulation to the south, in Arroyo El Bulito (not designated as critical habitat), by 0.4 mi (0.7 km). SB–2 was occupied at the time of listing. This unit allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within Conception Recovery Unit. Furthermore, this unit, and units SB–3, SB–4, SB–5, and SB–6, likely act as a metapopulation as defined in the Background section. These units are no more than 2.0 mi (3.3 km) from each other, which facilitates higher dispersal rates between sites. Because these units are of relatively small size in area (1 to 9 ac (less than 1 to 4 ha)), they are more susceptible to drying or shrinking due to drought conditions, which increases the likelihood of local extirpation. Lastly, because these units are small, they are likely to be dependent upon some degree of periodic exchange of tidewater goby between units for any one unit to persist over time. Therefore, designation of critical habitat at these five locations is necessary for the conservation of the tidewater goby along the Gaviota Coast in Santa Barbara County. On an intermittent basis, SB–2 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SB–3: Canada de Santa Anita. SB–3 consists of 3 ac (1 ha). This unit is located in Santa Barbara County, approximately 5.2 mi (8.4 km) west of Gaviota. The unit consists entirely of private lands. SB–3 is located 2.0 mi (3.2 km) south of Can˜ ada de las Agujas (SB–2), and is separated from the nearest extant subpopulation to the north, in Can˜ ada del Agua (not designated as critical habitat), by 0.4 mi (0.7 km). SB–3 was occupied at the time of listing. This unit is important to the conservation of the species because it allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within the Conception Recovery Unit. Furthermore, as described above in SB– 2, this unit, and units SB–2, SB–4, SB– 5, and SB–6, likely act as a metapopulation as defined in the Background section, and designation of critical habitat at these five locations is necessary for the conservation of the tidewater goby along the Gaviota Coast in Santa Barbara County. On an intermittent basis, SB–3 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SB–4: Canada de Alegria. SB–4 consists of 2 ac (1 ha). This unit is located in Santa Barbara County, approximately 3.2 mi (5.1 km) west of Gaviota. The unit consists entirely of private lands. SB–4 is located 2.0 mi (3.3 km) south of Can˜ ada de Santa Anita (SB–3), and is separated from the nearest extant subpopulation to the south, in Can˜ ada del Agua Caliente (SB– 5), by 1.1 mi (1.8 km). SB–4 was occupied at the time of listing. This unit is important to the conservation of the species because it allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics in this region. Furthermore, as described above in SB– 2, this unit, and units SB–2, SB–3, SB– 5, and SB–6, likely act as a metapopulation as defined in the Background section, and designation of critical habitat at these five locations is necessary for the conservation of the tidewater goby along the Gaviota Coast in Santa Barbara County. On an intermittent basis, SB–4 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SB–5: Canada del Agua Caliente. SB–5 consists of 1 ac (less than 1 ha). This unit is located in Santa Barbara County, approximately 2.1 mi (3.4 km) west of Gaviota. This unit consists entirely of private lands. SB–5 is located 1.1 mi (1.8 km) south of Can˜ ada de Alegria (SB–4), which is also the nearest extant subpopulation. SB–5 was occupied at the time of listing. This critical habitat unit provides habitat for a tidewater goby subpopulation that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). This unit helps conserve genetic diversity within the species. This unit also allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics in this region. Furthermore, as described above in SB–2, this unit, and units SB– 2, SB–3, SB–4, and SB–6, likely act as a metapopulation as defined in the Background section, and designation of critical habitat at these five locations is necessary for the conservation of the tidewater goby along the Gaviota Coast in Santa Barbara County. On an intermittent basis, SB–5 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SB–6: Gaviota Creek. SB–6 consists of 11 ac (5 ha). This unit is located in Santa Barbara County, approximately 0.8 mi (1.3 km) west of Gaviota. This unit consists of 10 ac (4 ha) of State lands and 1 ac (less than 1 ha) of private lands. SB–6 is located 1.5 mi (2.4 km) south of Can˜ ada del Agua Caliente (SB–5), which is also the nearest extant subpopulation. SB–6 was occupied at the time of listing. This unit is important to the conservation of the species because maintaining it will reduce the chance of losing the tidewater goby within the Conception Recovery Unit. It also allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics in this region. Furthermore, as described above in SB– 2, this unit, and units SB–2, SB–3, SB– 4, and SB–5, likely act as a metapopulation as defined in the Background section, and designation of critical habitat at these five locations is necessary for the conservation of the tidewater goby along the Gaviota Coast in Santa Barbara County. On an intermittent basis, SB–6 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SB–7: Arroyo Hondo. SB–7 consists of 1 ac (less than 1 ha). This unit is located in Santa Barbara County, approximately 5.0 mi (8.0 km) east of Gaviota. This unit consists entirely of private lands. SB–7 is located 5.0 mi (8.0 km) south of Gaviota Creek (SB–6), and is separated from the nearest extant subpopulation to the south, in Arroyo Quemado (not designated as critical habitat), by 1.3 mi (2.0 km). This unit is outside the geographical area occupied by the species at the time of listing, but is considered to be currently occupied. This unit is essential for the conservation of the species because it provides habitat to nearby units and could provide habitat for maintaining the tidewater goby metapopulation within the Conception Recovery Unit. Maintaining this unit will reduce the chance of losing the tidewater goby within the Conception Recovery Unit, and help conserve genetic diversity within the species. Although SB–7 is outside the geographical area occupied at the time of listing, it does possess the PCE that supports tidewater goby. On an intermittent basis, SB–7 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SB–8: Winchester/Bell Canyon. SB–8 consists of 6 ac (3 ha). This unit is located in Santa Barbara County, approximately 2.2 mi (3.5 km) west of the community of El Encanto Heights. The unit consists of 1 ac (less than 1 ha) of local lands and 5 ac (2 ha) of private lands. SB–8 is located 6.0 mi (9.6 km) north of Goleta Slough (SB–9), and is separated from the nearest extant subpopulation to the north, Tecolote Canyon (not designated as critical habitat), by 0.3 mi (0.4 km). SB–8 was occupied at the time of listing. This unit is important to the conservation of the species because it allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics in this region. On an intermittent basis, SB–8 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SB–9: Goleta Slough. SB–9 consists of 190 ac (76 ha). This unit is located in Santa Barbara County, within the City of Goleta. The unit consists of 164 ac (66 ha) of local lands and 26 ac (10 ha) of private lands. SB– 9 is located 6.0 mi (9.6 km) south of Winchester/Bell Canyon (SB–8), and is separated from the nearest extant subpopulation to the north, Devereux Slough (not designated as critical habitat), by 4.0 mi (6.4 km). This unit is outside the geographical area occupied by the species at the time of listing, but is currently occupied. This unit is essential for the conservation of the species because it provides habitat for the species, allows for connectivity between tidewater goby source populations from nearby units, supports gene flow, and provides for metapopulation dynamics within the Conception Recovery Unit. Although SB–9 is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, SB–9 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SB–10: Arroyo Burro. SB–10 consists of 3 ac (1 ha). This unit is located in Santa Barbara County, approximately 3.6 mi (5.8 km) west of the City of Santa Barbara. The unit consists entirely of local lands. SB–10 is located 4.0 mi (6.4 km) north of Mission Creek–Laguna Channel (SB–11), which is also the nearest extant subpopulation. This unit is outside the geographical area occupied by the species at the time of listing, but is considered to be currently occupied. This unit is essential for the conservation of the species because it provides habitat for the species, allows for connectivity between tidewater goby source populations from nearby units, supports gene flow, and provides for metapopulation dynamics within the Conception Recovery Unit. Although SB–10 is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, SB–10 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SB–11: Mission Creek–Laguna Channel. SB–11 consists of 7 ac (3 ha). This unit is located in Santa Barbara County, within the City of Santa Barbara. The unit consists of 3 ac (1 ha) of State lands and 4 ac (2 ha) of local lands. SB–11 is located 4.0 mi (6.4 km) south of Arroyo Burro (SB–10), and is separated from the nearest extant subpopulation to the south, in Sycamore Creek (not designated as critical habitat), by 1.0 mi (1.5 km). SB–11 was occupied at the time of listing. The tidewater goby subpopulation in SB–11 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the Conception Recovery Unit. On an intermittent basis, SB–11 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

SB–12: Arroyo Paredon. SB–12 consists of 3 ac (1 ha). This unit is located in Santa Barbara County, within the City of Santa Barbara. The unit consists of 1 ac (less than 1 ha) of State lands, 1 ac (less than 1 ha) of local lands, and 1 ac (less than 1 ha) of private lands. SB–12 is located 8.0 mi (12.8 km) south of Mission CreekLaguna Channel (SB–11), and is separated from the nearest extant subpopulation to the south, in Carpinteria Creek (not designated as critical habitat), by 2.7 mi (4.3 km). This unit is outside the geographical area occupied by the species at the time of listing, but is considered to be currently occupied. This unit is essential for the conservation of the species because it provides habitat for the species, allows for connectivity between tidewater goby source populations from nearby units, supports gene flow, and provides for metapopulation dynamics within the Conception Recovery Unit. Although SB–12 is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, SB–12 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

VEN–1: Ventura River. VEN–1 consists of 50 ac (21 ha). This unit is located in Ventura County, within the City of Ventura. The unit consists of 25 ac (10 ha) of State lands, 16 ac (7 ha) of local lands, and 9 ac (4 ha) of private lands. VEN–1 is located 4.3 mi (7.0 km) north of the Santa Clara River (VEN–2), which is also the nearest extant subpopulation. VEN–1 was occupied at the time of listing. The tidewater goby population in this unit is likely a source population and is, therefore, important for maintaining metapopulation dynamics. This critical habitat unit provides habitat for a tidewater goby subpopulation that is important to the conservation of one of the genetically distinct recovery units as described in the Recovery Plan (Dawson et al. 2001, p. 1172). Maintaining this unit will reduce the chance of losing the tidewater goby within the LA/Ventura Recovery Unit, and help conserve genetic diversity within the species. On an intermittent basis, VEN–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

VEN–2: Santa Clara River. VEN–2 consists of 323 ac (130 ha). This unit is located in Ventura County, approximately 4 mi (6.4 km) southeast of the City of Ventura. This unit consists of 199 ac (80 ha) of State lands, 14 ac (6 ha) of local lands, and 110 ac (44 ha) of private lands. VEN–2 is located 4.3 mi (7.0 km) south of the Ventura River unit (VEN–1), which is also the nearest extant subpopulation. VEN–2 was occupied by tidewater goby at the time of listing. The tidewater goby subpopulation in VEN–2 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the LA/Ventura Recovery Unit Recovery Unit. This unit is known to have tens of thousands of tidewater goby during certain times of the year (Dellith, pers. comm. 2010), and is considered one of the largest tidewater goby populations in southern California. On an intermittent basis, VEN–2 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

VEN–3: J Street Drain–Ormond Lagoon. VEN–3 consists of 121 ac (49 ha). This unit is located in Ventura County, approximately 1 mi (1.6 km) east of Port Hueneme. This unit consists of 5 ac (2 ha) of State lands, 49 ac (20 ha) of local lands, and 67 ac (27 ha) of private lands. VEN–3 is located 4.3 mi (6.9 km) south of the Santa Clara River (VEN–2), which is also the nearest extant subpopulation. VEN–3 was occupied at the time of listing. This unit allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within the LA/Ventura Recovery Unit. On an intermittent basis, VEN–3 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

VEN–4: Big Sycamore Canyon [Note that the Recovery Plan refers to this location as ‘‘Sycamore Canyon’’]. VEN–4 consists of 1 ac (less than 1 ha). This unit is located in Ventura County, approximately 12.0 mi (19.3 km) northwest of the City of Malibu. The unit consists entirely of

State lands. VEN–4 is located 5.0 mi (8.0 km) north of Arroyo Sequit (LA–1), and is separated from the nearest extant subpopulation to the north, in the Calleguas Creek (not designated as critical habitat), by 5.0 mi (8.0 km). This unit is outside the geographical area occupied by the species at the time of listing, but is considered to be currently occupied. This unit is essential for the conservation of the species because it provides habitat for the species, allows for connectivity between tidewater goby source populations from nearby units, supports gene flow, and provides for metapopulation dynamics within the LA/Ventura Recovery Unit. Although VEN–4 is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, VEN–4 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

LA–1: Arroyo Sequit. LA–1 consists of 1 ac (less than 1 ha). This unit is located in Los Angeles County, approximately 7.5 mi (12.0 km) northwest of the City of Malibu. The unit consists entirely of State lands. LA– 1 is located 5.0 mi (8 km) south of Big Sycamore Canyon (VEN–4), which is the nearest extant subpopulation. This unit is outside the geographical area occupied by the species at the time of listing, is not known to be currently occupied, and there are no historical tidewater goby records for this location. However, this unit is essential for the conservation of the species because it is identified in the Recovery Plan as a potential introduction site, and could provide habitat for maintaining the tidewater goby metapopulation in the region. This unit will provide habitat for tidewater goby that may be introduced, which may serve to decrease the risk of extirpation of this metapopulation through stochastic events. This unit would also allow for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within the LA/Ventura Recovery Unit. Although LA–1 is outside the geographical area occupied at the time of listing and is not currently occupied, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, LA–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

LA–2: Zuma Canyon. LA–2 consists of 5 ac (2 ha). This unit is located in Los Angeles County, approximately 7.5 mi (12.0 km) northwest of the City of Malibu. The unit consists entirely of local lands administered by Los Angeles County. LA–2 is located 6.8 mi (11 km) south of Arroyo Sequit (LA–1), and is separated from the nearest extant subpopulation to the south, in the Malibu Lagoon (LA–3), by 10.0 mi (16.0 km). LA–2 is outside the geographical area occupied by the species at the time of listing, is not known to be currently occupied, and there are no historical tidewater goby records for this location. However, this unit is essential for the conservation of the species because it could provide habitat to nearby occupied units and is identified in the Recovery Plan as a potential introduction site, and it could provide habitat for maintaining the tidewater goby metapopulation within the LA/ Ventura Recovery Unit. This unit will provide habitat for tidewater goby that are introduced, which may serve to decrease the risk of extirpation of this metapopulation through stochastic events. This unit would also allow for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within the LA/Ventura Recovery Unit. Although LA–2 is outside the geographical area occupied at the time of listing and is not currently occupied, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, LA–2 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

LA–3: Malibu Lagoon. LA–3 consists of 64 ac (27 ha). This unit is located in Los Angeles County, approximately 0.6 mi (1 km) east of Malibu Beach. The unit consists of 41 ac (27 ha) of State lands, 1 ac (less than 1 ha) of local lands, and 22 ac (9 ha) of private lands. LA–3 is located 6.0 mi (9.6 km) north of Topanga Canyon (LA– 4), which is also the nearest extant subpopulation. LA–3 was occupied at the time of listing. The tidewater goby subpopulation in LA–3 is likely a source population, which is important in maintaining metapopulation dynamics, and hence the long-term viability, of the LA/Ventura Recovery Unit. LA–3 supports one of the two remaining extant populations of tidewater goby within Los Angeles County. On an intermittent basis, LA–3 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation. The physical or biological features essential to the conservation of the species in this unit may require special management considerations or protection to address threats.

LA–4: Topanga Creek. LA–4 consists of 6 ac (2 ha). This unit is located in Los Angeles County, approximately 5.5 mi (8.9 km) northwest of the City of Santa Monica. The unit consists of 4 ac (1 ha) of State lands and 2 ac (1 ha) of private lands. LA–4 is located 6.0 mi (9.6 km) south of Malibu Lagoon (LA–3), which is also the nearest extant subpopulation. This unit is outside the geographical area occupied by the species at the time of listing, but is currently occupied. Tidewater gobies were first detected at this locality in 2001 (Service 2005a, p. C–30). Tidewater goby in Topanga Creek are probably derived from fish that dispersed from Malibu Creek. This unit is essential for the conservation of the species because it allows for connectivity between tidewater goby source populations, and thereby supports gene flow and metapopulation dynamics within the LA/Ventura Recovery Unit. This location is one of the two remaining locations in Los Angeles County known to be occupied by tidewater goby. Although LA–4 is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, LA–4 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

OR–1: Aliso Creek. OR–1 consists of 14 ac (5 ha). This unit is located in Orange County, within the City of Laguna Beach. The unit consists of 8 ac (3 ha) of local lands and 6 ac (2 ha) of private lands. OR–1 is located 13.5 mi (21.7 km) north of the San Mateo Creek (not designated as critical habitat, see Application of Section 4(a)(3) of the Act—Marine Corps Base Camp Pendleton section below), which supports the nearest extant subpopulation. This unit is outside the geographical area occupied by the species at the time of listing, and is not known to be currently occupied. OR–1 was last known to be occupied in 1977 (Swift et al. 1989, p. 1). The reason for the extirpation of the historical subpopulation at this site is unknown. However, this unit is essential for the conservation of the species because it would aid recovery of the tidewater goby in the genetically unique South Coast Recovery Unit. The Recovery Plan notes that the species should be reintroduced into as many localities as possible to the north and south of MCB Camp Pendleton (Service 2005a, p. G– 16). Aliso Creek is identified in the Recovery Plan as a potential reintroduction site (Service 2005a, p. G– 20). If tidewater goby become established at this location, this unit's primary function would be to help maintain the genetic diversity of the Southern Coast Recovery Unit (especially Recovery Subunit SC1). Moreover, a level of population redundancy would help prevent the extirpation of a metapopulation in which only one or two occupied sites remain, which is the case for Recovery Subunit SC1. Although OR–1 is outside the geographical area occupied at the time of listing and is not currently occupied, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, OR–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

SAN–1: San Luis Rey River. SAN–1 consists of 56 ac (23 ha). This unit is located in San Diego County, within the City of Oceanside. The unit consists of 3 ac (1 ha) of State lands, 49 ac (20 ha) of local lands, and 4 ac (2 ha) of private lands. SAN–1 is located approximately 2.5 mi (4.0 km) south of the Santa Margarita River (not designated as critical habitat; see Application of Section 4(a)(3) of the Act—Marine Corps Base Camp Pendleton section below), which supports the nearest known extant subpopulation. This unit is outside the geographical area occupied by the species at the time of listing, but tidewater gobies were detected at this location in 2010 (Lafferty 2010, not paginated), which indicates that this location is one of the suite of occupied and intermittently occupied locations that contributes to tidewater goby metapopulation on MCB Camp Pendleton. This unit is essential for the conservation of the species because it serves as one of a limited number of locations that contribute toward metapopulation dynamics of the genetically unique South Coast Recovery Unit. As discussed in the Metapopulation Dynamics section, the number of subpopulations is important to the long-term stability of a metapopulation. As such, SAN–1 will help the species to survive and support the recovery of the tidewater goby population within the South Coast Recovery Unit, even potentially facilitating natural recolonization of currently unoccupied locations to the south. The Recovery Plan notes that the species should be reintroduced into as many localities as possible to the north and south of MCB Camp Pendleton (Service 2005a, p. G–16). The San Luis Rey River was identified in the Recovery Plan as a potential reintroduction site (Service 2005a, p. G– 20). Prior to 2010, tidewater gobies were last detected in this unit in 1958 (Lafferty, pers. comm. 2010). This unit now represents the southernmost occupied area of the species' distribution, and is important for maintaining the tidewater goby metapopulation in the region. Although SAN–1 is outside the geographical area occupied at the time of listing, it does possess the PCE that is needed to support tidewater goby. On an intermittent basis, SAN–1 possesses a sandbar across the mouth of the lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, and thereby provides relatively stable conditions (PCE 1c). PCE 1a and 1b occur throughout the unit, although their precise location during any particular time period may change in response to seasonal fluctuations in precipitation and tidal inundation.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the primary constituent element of the physical or biological features essential to the conservation of tidewater goby consist of persistent, shallow (in the range of approximately 0.3 to 6.6 ft (0.1 to 2 m)), still-to-slow-moving lagoons, estuaries, and coastal streams with salinity up to 12 parts per thousand (ppt), which provides adequate space for normal behavior and individual and population growth that contain:

(i) Substrates (e.g., sand, silt, mud) suitable for the construction of burrows for reproduction;

(ii) Submerged and emergent aquatic vegetation, such as Potamogeton pectinatus, Ruppia maritima, Typha latifolia, and Scirpus spp., that provides protection from predators and high flow events; or

(iii) Presence of a sandbar(s) across the mouth of a lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, thereby providing relatively stable water levels and salinity.

Special Management Considerations or Protections

Critical habitat does not include manmade structures (such as bridges, docks, aqueducts, and other paved areas) and the land on which they are located existing within the legal boundaries on March 8, 2013.

Some of the special management actions that may be needed for essential features of tidewater goby habitat are briefly summarized below. (1) Implement measures to avoid, minimize or mitigate direct and indirect loss and modification of tidewater goby habitat due to dredging, draining, and filling of lagoons and estuaries. Additional management actions should be taken to restore historical tidewater goby locations and potential habitats as opportunities become available to eliminate, minimize, or mitigate the effects of existing structures and past activities that have destroyed or degraded tidewater goby habitat. (2) Develop and implement measures to minimize the adverse effects due to channelization that can eliminate crucial backwater habitats or other flood refuges. (3) Implement measures, such as best management practices, for managing excessive sedimentation in tidewater goby habitat. Measures should be implemented to control sedimentation in tidewater goby habitat due to cattle grazing, development, channel modification, recreational activity, and agricultural practices. (4) Implement measures to prevent further decrease in freshwater inflow, water depth, and surface area within tidewater goby habitat due to dams, water diversions, and groundwater pumping. (5) Implement measures to avoid anthropogenic breaching of lagoons and use of pumping and other water control structures to regulate water levels, to maintain suitable habitat conditions during the summer and fall when tidewater goby reproduction is at its highest and freshwater inflow is at its lowest. (6) Implement measures to improve water quality degraded as a result of agricultural runoff and effluent, municipal runoff, golf course runoff, sewage treatment effluent, cattle grazing, development, oil spills, oil field runoff, toxic waste, and gray-water dumping. Also, measures should be implemented to prevent further degradation of the water quality due to dikes, tidal gates, and other impedances to the natural freshwater/saltwater interface that alter the salinity regime in some of the tidewater goby habitats. (7) Implement measures to control the abundance and distribution of nonnative species. (8) Implement measures to restore genetic diversity within populations where the natural metapopulation dynamic will be unable to do so.

Life History

Feeding Narrative

Juvenile: See Adult narrative.

Adult: Juvenile tidewater gobies are opportunistic omnivores that feed on green algae (Chlorophyta and Charophyta), rotifers (Rotifera), and brine shrimp larvae (Artemia); while adults are opportunistic invertivores that feed on mysid shrimp (Mysida), gammarid amphipods (Gammaridea), ostracods or seed shrimp (Ostracoda), and aquatic insects (especially chironomid midge larvae [Chironomidae]). Both juveniles and adults generally use three styles of feeding: plucking prey from the surface of the substrate, sifting sediment in their mouths, and mid-water capture. Juveniles are generally day feeders, while adults prefer to feed at night. Adults experience resource competition from closely-related estuarine fish, particularly rainwater killifish (Lucania parva), chameleon goby (Tridentiger trigonocephalus), and yellowfin goby (Acanthogobius flavimanus) (USFWS 2005).

Reproduction Narrative

Juvenile: See Adult narrative.

Adult: Male gobies dig a vertical nesting burrow 10 to 20 cm (4 to 8 in.) deep in clean, coarse sand in May or April after lagoons close to the ocean (59 FR 5494; USFWS 2007). Female tidewater gobies aggressively spar with each other for access to males with burrows where they may lay their eggs (USFWS 2005). Reproduction occurs at all times of the year so long as water temperatures are between 9 and 25 °C (48 to 77 °F) and salinities are between 2 and 27 ppt (USFWS 2007). The peak of spawning activity occurs during the spring, and then again in the late summer (USFWS 2007). Fluctuations in reproduction are probably due to death of breeding adults in early summer and colder temperatures or hydrological disruptions in winter (USFWS 2007). Each female lays 300 to 500 eggs per clutch, and typically lays 6 to 12 clutches in a year (USFWS 2005). Male gobies remain in the burrows to guard eggs, which are hung from the ceiling and walls of the burrow, for approximately 9 to 11 days until they hatch (59 FR 5494; USFWS 2005). Tidewater gobies have a standard length of approximately 4 to 5 mm (0.17 to 0.25 in.) when they hatch, and hatchlings are planktonic (drifting or swimming weakly within any portion of the water column) for 1 to 3 days before becoming benthic (living primarily along the bottom of a body of water) (USFWS 2005).

Geographic or Habitat Restraints or Barriers

Juvenile: Marine conditions (although they are able to migrate through such conditions for short periods of time).

Adult: Marine conditions (although they are able to migrate through such conditions for short periods of time).

Spatial Arrangements of the Population

Juvenile: Larval gobies are found midwater around vegetation until they become benthic (59 FR 5494).

Adult: Clumped; tidewater gobies occur in loose aggregations of a few to several hundred individuals on the substrate in shallow water less than 1 meter (m) (3 feet [ft.]) deep (59 FR

5494).

Environmental Specificity

Juvenile: Narrow

Adult: Narrow

Tolerance Ranges/Thresholds

Juvenile: High; tidewater gobies can tolerate a wide range of salinity and water quality conditions (USFWS 2007).

Adult: High; tidewater gobies can tolerate a wide range of salinity and water quality conditions (USFWS 2007).

Site Fidelity

Juvenile: High

Adult: High

Habitat Narrative

Juvenile: See Adult narrative.

Adult: Suitable conditions for tidewater gobies occur in two relatively distinct situations: 1) the upper edge of tidal bays near the entrance of freshwater tributaries; and 2) the coastal lagoons formed at the mouths of coastal rivers, streams, or seasonally wet canyons (USFWS 2005). Tidewater goby habitat is subject to considerable fluctuation of physical factors on both a daily and a seasonal basis as a result of winter rains, flooding, scouring and sedimentation, and breaching of lagoons (USFWS 2005). Like many organisms in fluctuating environments, tidewater gobies can tolerate a wide range of salinity and water quality conditions (USFWS 2007). Lagoons are usually least saline during winter and spring rainy seasons due to precipitation, and temperatures seldom exceed a range of 10 to 25°C (50 to 77°F) (USFWS 2005). All life stages of tidewater gobies are most concentrated at the upper end of lagoons in salinities less than 12 ppt, although they range upstream a short distance into fresh water, and downstream into water of up to about 75 percent sea water (28 ppt) (USFWS 2005).In the spring and summer, stable lagoons are often almost completely choked with aquatic vegetation; this is virtually entirely removed during the fall and winter, when it is consumed by migrating waterfowl or washed out by the breaching of lagoons that occurs during winter flood events (USFWS 2005). Aquatic vegetation provides cover from predators, and substrate for the invertebrates on which tidewater gobies feed (USFWS 2005). Larval gobies are found midwater around vegetation until they become benthic (59 FR 5494). Adult tidewater gobies occur in loose aggregations of a few to several hundred individuals on the substrate in shallow water less than 1 m (3 ft.) deep (59 FR 5494). Tidewater goby habitat has been lost and degraded due to coastal development, among other factors, and their movement is limited by their avoidance of marine conditions, although some dispersal through marine conditions is possible.

Dispersal/Migration

Motility/Mobility

Juvenile: Moderate

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Nonmigratory

Adult: Nonmigratory

Dispersal

Juvenile: Moderate; often move upstream into tributaries as far as 1.0 km (0.5 mi.) from the estuary. Half-grown to adult tidewater gobies move upstream in the summer and fall, and there is evidence that reproduction occurs in these upstream tributaries (USFWS 2005).

Adult: Moderate; tidewater gobies often move upstream into tributaries as far as 1.0 km (0.5 mi.) from the estuary. Half-grown to adult tidewater gobies move upstream in the summer and fall, and there is evidence that reproduction occurs in these upstream tributaries (USFWS 2005).

Immigration/Emigration

Juvenile: Moderate; evidently can disperse through at least several km (couple of mi.) of unsuitable marine habitat to reach isolated lagoons (NatureServe 2015).

Adult: Moderate; tidewater gobies evidently can disperse through at least several km of unsuitable marine habitat to reach isolated lagoons (NatureServe 2015).

Dependency on Other Individuals or Species for Dispersal

Juvenile: No

Adult: No

Dispersal/Migration Narrative

Juvenile: See Adult narrative.

Adult: The lagoons in which tidewater gobies are found range in size from a few m2 (several sq. ft.) to about 800 ha (2,000 ac.) (USFWS 2005). Most lagoons are much smaller, ranging from about 0.5 to 5 ha (1.25 to 12.5 ac.) (USFWS 2005). Tidewater gobies often move upstream into tributaries, as far as 1.0 km (0.5 mi.) from the estuary (USFWS 2005). Half-grown to adult tidewater gobies move upstream in the summer and fall, and there is evidence that reproduction occurs in these upstream tributaries (USFWS 2005). Tidewater gobies, although nonmigratory, evidently can disperse through at least several km (several mi.) of unsuitable marine habitat to reach isolated lagoons (NatureServe 2015).

Additional Life History Information

Juvenile: The lagoons in which tidewater gobies are found range in size from a few square meters (m2) (several square feet [sq. ft.]) to about 800 hectares (ha) (2,000 acres [ac.]). Most lagoons are much smaller, ranging from about 0.5 to 5 ha (1.25 to 12.5 ac.) (USFWS 2005).

Adult: The lagoons in which tidewater gobies are found range in size from a few m2 (several sq. ft.) to about 800 ha (2,000 ac.). Most lagoons are much smaller, ranging from about 0.5 to 5 ha (1.25 to 12.5 ac.) (USFWS 2005).

Population Information and Trends

Population Trends:

Unknown; trend over the past 10 years is uncertain, but probably within the natural range of variation (NatureServe 2015).

Species Trends:

Unknown; no range-wide, long-term monitoring program is currently being conducted for the tidewater goby, and data on population dynamics are limited (USFWS 2007).

Population Growth Rate:

Unknown

Number of Populations:

Occurred historically in at least 135 localities; it is thought that there are currently about 114 extant populations (78 FR 8746).

Population Size:

The total adult population size is unknown, but likely at least several thousand (NatureServe 2015). Estimates of population size are generally lacking due to the constant variability of local abundance. Seasonal changes in distribution and abundance further hamper efforts to estimate population size for this short-lived species (USFWS 2007).

Resistance to Disease:

Low

Additional Population-level Information:

Tidewater goby populations along the California coast occur as metapopulations, groups of distinct populations that are genetically interconnected through occasional exchange of animals (USFWS 2007).

Population Narrative:

Historically, tidewater gobies occurred in at least 135 localities. It is thought that there are currently 114 extant populations, with a total abundance of several thousand individuals (78 FR 8746). The species has likely fluctuated in abundance within the range of natural variation over the past 10 years, although the level of fluctuation is unknown (NatureServe 2015). No range-wide, long-term monitoring program is currently being conducted for the tidewater goby, and data on population dynamics are limited (USFWS 2007). Estimates of population size are generally lacking due to the constant variability of local abundance (USFWS 2007). Seasonal changes in distribution and abundance further hamper efforts to estimate population size for this short-lived species (USFWS 2007).Experts believe that tidewater goby populations (i.e., localities) along the California coast occur as metapopulations. A metapopulation is defined as a group of distinct populations that are genetically interconnected through occasional exchange of animals. Although individual populations may be periodically extirpated under natural conditions, a metapopulation is likely to persist through colonization or recolonization events that establish new populations. It is believed that some tidewater goby populations persist on a consistent basis (potential sources of individuals for recolonization), while other tidewater goby populations appear to experience intermittent extirpations (USFWS 2007).

Threats and Stressors

Stressor: Coastal development projects resulting in the loss or alteration of coastal wetland habitat
Exposure: Coastal development.
Response: Loss and degradation habitat.
Consequence: Isolation of populations and population decline.
Narrative: Historically, tidewater gobies likely occurred in far more localities than at present. An estimated 75 to 90 percent of estuarine wetlands have been lost in California. The habitat at many of these historic localities was probably entirely lost to development (e.g., harbors, channels, agriculture, industrial and business uses, residential development, and road construction) before surveys for tidewater gobies were being conducted. The dramatic destruction of estuarine and coastal wetland habitat that occurred in the past has largely or entirely been eliminated as a result of current laws and regulations protecting coastal habitats. Although major habitat loss is now unlikely, a limited amount of habitat will continue to be altered, which in turn will result in limited impacts on tidewater goby. Examples of ongoing or imminent activities within tidewater goby habitat include annual dredging, habitat restoration projects, and bridge-widening projects. Although we expect the impact of these activities to be limited, even small projects can potentially have significant effects (USFWS 2007).

Stressor: Hydrological changes
Exposure: Human activities leading to hydrological changes (channelization, water diversion, groundwater pumping, and restoration projects).
Response: Loss and degradation of habitat, changes in salinity.
Consequence: Decline in abundance, survival, and productivity.
Narrative: Hydrological changes, including actions such as channelization, water diversions, and groundwater pumping, and in some cases restoration projects, can degrade tidewater goby habitat. Channelization can diminish downstream marsh habitat and lead to loss of populations by flushing them out to sea during high flow events; by scouring of stream channels, which may eliminate or reduce the substrate needed for burrows; and by changes in salinity regimes, which may affect tidewater goby abundance, survival, and productivity. Although channelization and habitat removal is continuing throughout the state within the coastal zone, the degree of impact of these activities on habitat is less severe than prior to the listing of the species. In addition, improvements in technology have further reduced impacts. Water diversions and groundwater pumping can change flow rate, which can cause a reduction in freshwater input into lagoons and estuaries. They can also change the timing of water availability and alter downstream salinity regimes. Dredging has been attributed to both direct habitat loss and salinity changes. Road construction along coastlines has severed tidal influx, altering both salinity and temperature profiles. Although these impacts are ongoing, the degree of impact they may be having on tidewater gobies is unclear (USFWS 2007).

Stressor: Sedimentation of lagoons
Exposure: Urban and coastal development near coastal lagoons.

Response: Increased sedimentation, leading to shallower water.
Consequence: Temperature fluctuations, more frequent breaching, and loss of habitat.
Narrative: Urban and commercial development adjacent to or upstream from coastal lagoons can lead to increased sedimentation, potentially raising the elevation of the lagoon bottom and subsequently decreasing lagoon depth. The shallower water may allow water temperatures to fluctuate between higher and lower extremes, which may affect tidewater gobies. Although tidewater gobies may be adapted to a wide range in temperature, the abundance of other fish, including predators and competitors, may increase as a result of temperature changes. Shallower lagoons of finite width also have reduced storage capacity, and therefore the same amount of fresh water flowing into the estuary may breach the sandbar more quickly, which could be at times outside the natural, historic norms. This change in breach timing may impact tidewater gobies by reducing habitat for breeding, foraging, and cover; exposing nest burrows; and flushing adults and juveniles out to sea. Conversely, reduced storage capacity may allow lagoons with limited inflows to dry out. In addition, the trend in estuary restoration has been to create more open tidal settings via jetties and dredging, thus eliminating the potential for the seasonally closed habitat on which tidewater gobies depend. The impacts listed above may potentially have an effect on tidewater gobies; however, information on the occurrence and magnitude of these threats is not available (USFWS 2007).

Stressor: Predation by nonnative species
Exposure: Introduction of nonnative predators.
Response: Increased rates of predation.
Consequence: Decline in abundance.
Narrative: A major source of introduced species is the spread from ballast water from ocean-going ships. The California Department of Fish and Wildlife (CDFW) conducted nonindigenous species investigations in marine and estuarine waters of California, and found numerous introduced predatory species. These species included striped bass (Morone chrysops), white catfish (Amerius catus), largemouth bass (Micropterus notius), common carp (Cyprinus carpio), threadfin shad (Dorosoma petenense), redear sunfish (Lepomis microlophus), black crappie (Pomoxis nigromaculatus), bluegill (Lepomis macrochirus), and inland silverside (Menidia beryllina). The species considered to pose the greatest threats of predation include largemouth and smallmouth bass (Micropterus dolomieni), which have been identified in the CDFW surveys. Centrarchids (fish in the sunfish family) are known predators of tidewater gobies, and are documented as having led to the extirpation of tidewater gobies in several localities. Nonnative amphibians, such as African clawed frogs (Xenopus laevis), also prey upon tidewater gobies (USFWS 2007).

Stressor: Parasitism
Exposure: Presence fluke (Cryptocotyle lingua).
Response: Mortality or increased vulnerability to predation.
Consequence: Decline in abundance.
Narrative: The only parasite recorded on tidewater gobies is the fluke (Cryptocotyle lingua), which occurred on the skin of many adults from Corcoran Lagoon and possibly Pescadero Lagoon. Cryptocotyle lingua is a common marine parasite in the family Heterophyidae. At high intensities, the infection can kill the host fish, particularly juveniles, or facilitate secondary bacterial infections in the ruptured skin. In addition to pathological impacts, infection could increase the fish’s vulnerability to predation, either by increased visibility because of the black cysts, or by altered predator-avoidance behavior (USFWS 2005).

Stressor: Drought
Exposure: Drought
Response: Degradation of habitat.
Consequence: Decline in abundance and extirpation of populations.
Narrative: By far the most significant natural factors adversely affecting the tidewater goby are drought and the resultant alteration of coastal and riparian habitats. Periodic droughts are a historical feature of California, which has been repeatedly subject to prolonged droughts. Drought conditions, when combined with human-induced water reductions, have degraded coastal and riparian ecosystems and have created extremely stressful conditions for most aquatic species, including the tidewater goby. Drought can have dramatic negative effects on tidewater gobies, at least decreasing their populations to very low levels (perhaps to the point where they are undetectable), and at most extirpating populations (USFWS 2007).

Stressor: Small, isolated populations
Exposure: Small, isolated populations.
Response: Genetic drift, inbreeding, and loss of genetic diversity.
Consequence: Reduced fitness and increased extinction risk.
Narrative: The substantial destruction of coastal wetlands, lagoons, and estuaries in the past has resulted in many tidewater goby localities becoming more isolated. Genetic exchange within a metapopulation is also correspondingly limited, which may result in genetic drift and inbreeding. Loss of genetic diversity in small populations may decrease the potential for persistence in the face of long-term environmental change. Loss of genetic diversity can also result in decline in fitness from expression of deleterious recessive alleles. Change in the distribution of diversity can destroy local adaptations or break up coadapted gene complexes (outbreeding depression). These problems can lead to a poorer "match" of the organism to its environment, reducing individual fitness and increasing the probability of population or species extinction (USFWS 2007).

Stressor: Competition and predation by closely-related species
Exposure: Introduction and increase in abundance of closely-related species.
Response: Competition with and predation by closely-related species.
Consequence: Unknown; decline in abundance.
Narrative: Often, closely-related species compete for resources such as food and habitat, and may degrade native fish habitat. Several small, potentially competitive or predatory estuarine fishes have been introduced into tidewater goby habitat. Rainwater killifish (Lucania parva), chameleon goby (Tridentiger trigonocephalus), and yellowfin goby (Acanthogobius flavimanus) appeared in the 1960s in San Francisco Bay, coincident with the last collections of tidewater gobies there. Yellowfin gobies have slowly spread to many of the larger tidal and muddy California estuaries. The recent appearance of yellowfin gobies in southern California and the coincident disappearance of the tidewater goby in the Santa Margarita River in late 1993 suggest that the species is slowly spreading to brackish habitats, and may be eliminating tidewater gobies. Initial experiments indicated that shimofuri gobies (Tridentiger bifasciatus) aggressively intimidate, outcompete, and prey on tidewater gobies in the laboratory. However, like the chameleon goby, the shimofuri goby prefers hard substrates. Therefore, it might be expected to remain in such habitats in coastal lagoons, and perhaps not interact extensively with tidewater gobies. To date, the possible effects of interactions in the wild between these exotic goby species and tidewater gobies are largely conjectural (USFWS 2007).

Recovery

Reclassification Criteria:
Six regional clades based on morphological differences and supported by genetic data have been used to define Recovery Units for the tidewater goby: North Coast Unit, Greater Bay Unit, Central Coast Unit, Conception Unit, Los Angeles/Ventura Unit, and the South Coast Unit. Recovery Units are further divided into Sub-Units, which are defined as regions that are genetically different from each other. These Recovery Units and Sub-Units were used in the creation of reclassification and delisting criteria (USFWS 2005). On March 13, 2014, the species was proposed for reclassification as a threatened species (79 FR 14340).

The tidewater goby may be considered for downlisting when:

a) Specific threats to each metapopulation, such as habitat destruction and alteration (e.g., coastal development, upstream diversion, channelization of rivers and streams, and discharge of agriculture and sewage effluents), introduced predators (e.g., centrarchid fishes), and competition with introduced species (e.g., yellowfin and chameleon gobies), have been addressed through the development and implementation of individual management plans that cumulatively cover the full range of the species (USFWS 2005).

b) A metapopulation viability analysis based on scientifically credible monitoring over a 10-year period indicates that each Recovery Unit is viable. The target for downlisting is for individual Sub-Units within each Recovery Unit to have a 75 percent or better chance of persistence for a minimum of 100 years. Specifically, the target is for at least five Sub-Units in the North Coast Unit, eight Sub-Units in the Greater Bay Unit, three Sub-Units in the Central Coast Unit, three Sub-Units in the Conception Unit, one Sub-Unit in the Los Angeles/Ventura Unit, and two Sub-Units in the South Coast Unit to individually have a 75 percent chance of persisting for 100 years (USFWS 2005).

However, based on the 5-year review, the USFWS is now reconsidered the downlisting and delisting criteria in the recovery plan. The downlisting and delisting criteria require that a metapopulation viability analysis be conducted for each Sub-Unit. The USFWS now believes that other, currently available information on the species may also be used to determine the appropriate listing of the species under the ESA. These include the current number of occupied localities, current laws and regulations that act to protect the species, and our current understanding of threats and their impact on the tidewater goby (USFWS 2007).

Delisting Criteria:
Six regional clades based on morphological differences and supported by genetic data have been used to define Recovery Units for the tidewater goby: North Coast Unit, Greater Bay Unit, Central Coast Unit, Conception Unit, Los Angeles/Ventura Unit, and the South Coast Unit. Recovery Units are further divided into Sub-Units, which are defined as regions that are genetically different from each other. These Recovery Units and Sub-Units were used in the creation of reclassification and delisting criteria (USFWS 2005).

The tidewater goby may be considered for delisting when downlisting criteria have been met and a metapopulation viability analysis projects that all recovery units are viable (as in reclassification criteria b) except that the target for Sub-Units is a 95 percent probability of persistence for 100 years (USFWS 2005).

However, based on the 5-year review, we have now reconsidered the downlisting and delisting criteria in the recovery plan. The downlisting and delisting criteria require that a metapopulation viability analysis be conducted for each Sub-Unit. We now believe that other, currently available information on the species may also be used to determine the appropriate listing of the species under the Endangered Species Act (ESA). These include the current number of occupied localities, current laws and regulations that act to protect the species, and our current understanding of threats and their impact on the tidewater goby (USFWS 2007).

Recovery Actions:

- Protect and enhance currently occupied tidewater goby habitat by assessing the current status of extant tidewater goby populations and their habitat (including standardizing and implementing survey, sampling, and monitoring protocols for tidewater goby populations; standardizing and implementing protocols for assessing nonnative predator populations; and standardizing and implementing protocols for assessing impacts and sources of sedimentation in tidewater goby habitats) and managing extant tidewater goby habitat (including developing and implementing management strategies to avoid further direct net loss/modification of habitat; developing and implementing strategies for managing freshwater inflow within current or enhanced parameters; developing and implementing strategies for managing deleterious exotic species at current or reduced levels; developing and implementing strategies for managing adverse effects resulting from channelization at current or reduced levels; developing and implementing strategies for managing water quality within current or enhanced parameters; developing and implementing strategies for minimizing anthropogenic breaching of lagoons; developing and implementing strategies for managing excessive sedimentation in tidewater goby habitat within current or enhanced parameters; monitoring tidewater goby populations status and trends and habitat conditions; developing an umbrella Safe Harbor Agreement or obtaining financial incentives for landowners to maintain or enhance tidewater goby habitat; implementing regional ecosystem strategies through coordination, exchanging information, and existing regulatory processes to maximize the protection of tidewater goby habitat; and standardizing and implementing protocols for rescue of tidewater goby populations) (USFWS 2005).
- Conduct biological research to enhance the ability to integrate land use practices with tidewater goby recovery and revise recover tasks as pertinent new information becomes available, including determining water quality parameters for tidewater goby habitat; determining freshwater inflow parameters; investigating the interactions of exotic species with tidewater gobies; conducting studies to determine how to minimize the threats from nonnative predators; conducting studies to determine how to minimize the effects of channelization, sedimentation, and anthropogenic breaching; describing optimal tidewater goby habitat characteristics; determining the genetic diversity and intraspecific phylogeography of the tidewater goby; determining population demography characteristics for the tidewater goby; conducting annual aerial surveys to quantify habitat losses, identifying areas that have high potential for habitat creation/restoration, and acquiring electronics imagery for GIS applications; and practice adaptive management in which the U.S. Fish and Wildlife Service revises recovery tasks as pertinent new information becomes available. Adaptive management will include reevaluating recovery criteria, keeping the recovery plan current and useful, and revising maps on recovery Sub-Units as new genetic

data become available (USFWS 2005).

- Evaluate and implement translocation where appropriate by developing and refining protocols and guidelines for translocation, and implementing translocations in Sub-Units (USFWS 2005).
- Increase public awareness about tidewater gobies by preparing and distributing brochures and educational materials on the tidewater goby, and developing a website that will educate the public on the tidewater goby and recovery actions (USFWS 2005).
- Long-term monitoring plan: Assessment of the federal status of this species is difficult without a well-developed long-term monitoring plan. It is recommended that this plan be developed. Several sites have been monitored for the presence and absence of tidewater goby over the years. However, this does not allow for statistically-sound quantification of trends in population size across the species' range. This is due to varying degrees of sampling effort across the species range, and variation in sampling protocol. To this end, it is recommended that a long-term monitoring plan be developed dictating that: 1) sites are sampled in a common fashion throughout the species' range where possible, or at least sampled in such a way that comparisons can be made among sites based on catch per unit effort; and 2) a hierarchical sampling scheme be developed that dictates sampling in each Recovery Unit, Sub-Unit, and locality at specific intervals. Standardized reporting forms should be developed to ensure consistency of environmental data and reporting detail (USFWS 2007).
- Quantification of linkage between reduction in tidewater goby populations or habitat and incompatible coastal development practices: Many threats are identified throughout the literature and in the recovery plan. However, there is limited information on the linkage between specific habitat uses, such as development and agriculture, and reductions in habitat and number of tidewater goby localities (USFWS 2007).
- Quantification of effects of drought (or drier years) on presence of tidewater goby: A better understanding of the effect of drought on tidewater goby populations would be of value to the long-term assessment of the status of this species. Data from a well-developed monitoring plan and associated hydrologic data would aid in the development of this understanding (USFWS 2007).
- Delineation of populations: It is difficult to assess the number of populations, due to the frequent loss and re-colonization of sites. Additional molecular data would be useful to quantify among-population genetic structure and the existence of tidewater goby metapopulations. Furthermore, in the event that the populations in San Diego County are described as a new taxon, we should evaluate threats to both the tidewater goby and the new taxon. Based on the outcome of this evaluation, we would make a determination as to the listing status of the new taxon and the tidewater goby (USFWS 2007).
- Water quality monitoring plan: The development of a water quality monitoring plan for tidewater goby would allow better assessment of threats, and would provide data necessary to understand the link between water quality and tidewater goby population size. This plan could incorporate those data already gathered by state and federal entities required to assess water quality, and recommend areas for partnership (USFWS 2007).
- High priority recovery actions: Several recovery actions are identified in the Recovery Plan. Many of these focus on the need for increased data. However, there is also a need for habitat protection. It is recommended, as articulated in the Recovery Plan, that the development of management plans for Recovery Units be developed and subsequent habitat protection be implemented, as needed (USFWS 2007).

- Provide funding and technical support for development of metapopulation viability analyses: It is recommended, as articulated in the reclassification criteria of the Recovery Plan, that the development of metapopulation viability analyses be developed, which projects that all Recovery Units are viable. The goal of the metapopulation analysis is to identify particular subpopulations or localities, or links between localities that are critical to maintenance of the overall metapopulations (USFWS 2007).
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Additional Threshold Information:

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SPECIES ACCOUNT: *Fundulus julisia* (Barrens topminnow)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

The Barrens Topminnow is a small, colorful killifish that grows to 98mm (3.9 in). As is typical of the genus Fundulus, Barrens Topminnows have upturned mouths, flattened heads and backs, and rounded fins with the unpaired fins (i.e. dorsal and anal fins) set far back on the body (Etnier and Starnes 1993, pp. 360-361). The nuptial (reproductive) males are very showy with bright, iridescent background colors of greens, blues, with reddish orange spots and yellow fins as well as tubercles (hardened projections) on the anal fin rays (Figure 2.1). The females, juveniles and non-reproductive males are drabber with pale brown bodies sprinkled with darker spots on the sides (Williams and Etnier 1982; Etnier and Starnes 1993, pp. 365-366). For a detailed description of meristic characteristics and other morphological features, see Williams and Etnier (1982) and Etnier and Starnes (1993, p. 365) (USFWS, 2017).

Taxonomy

The Barrens Topminnow, Fundulus julisia, was first collected during Tennessee Valley Authority (TVA) preimpoundment surveys in the Duck River watershed near Manchester in 1938 (Rakes 1989, p.1). These specimens were cataloged as the closely related Whiteline Topminnow, F. albolineatus, though with some recognition that they represented an undescribed species. The species was described from by Williams and Etnier in 1982 and was placed in the subgenus Xenisma, and the type locality was designated as a spring on Joseph R. Banks' property (elsewhere referenced as “Summitville Mountain Spring” and Benedict Spring, the name used in this document). The species epithet (specific name), julisia, is derived from the Cherokee words for “watercress fish” in reference to the species preferred habitat in watercress and other aquatic vegetation (Williams and Etnier 1982, entire). The subgenus Xenisma contains fishes commonly referred to as studfishes, such as Northern Studfish (Fundulus catenatus), Southern Studfish (F. stellifer), and Stippled Studfish (F. bifax) as well as Barrens Topminnow and Whiteline Topminnow. Members of this group tend to be residents of backwaters and edges of streams. Barrens Topminnow is considered to be sister species to the now extinct Whiteline Topminnow (Rogers and Cashner 1987, entire). This fish was found only in Big Spring in Huntsville, AL until the 1890s and went extinct due to extensive changes in habitat (Boschung and Mayden 2003, p.384) (USFWS, 2017).

Historical Range

The Barrens Topminnow is historically known from the Barrens Plateau which is part of the Eastern Highland Rim in Middle Tennessee. Specimens of the species were originally found by L. F. Miller in 1937 during preimpoundment surveys for the TVA in the Duck River drainage (tributary to the Tennessee River) near Manchester and Tullahoma, Tennessee (Etnier and Dinkins 1983, entire; Etnier 1983, entire). Later surveys found the species at additional sites in the Elk River (tributary to the Tennessee River) drainage and the Caney Fork (tributary of the Cumberland River) drainage. Williams and Etnier formally described the species in 1982 from the type locality, Benedict Spring (Banks Spring) in the Hickory Creek watershed, part of the Caney Fork drainage. Sites were also found in the Duke Creek, Witty Creek, and Bullpen Creek watersheds within the Caney Fork drainage. Within the Elk River drainage, Pond Spring was identified as a robust population, but the only population in the drainage (Etnier 1983, p.3). From the first discovery in 1937 until the 1960s, sites were found in the Little Duck River watershed around Manchester, and in the Carroll Creek watershed around Tullahoma, both in the Duck River drainage (USFWS, 2017).

Current Range

TN; The most recent range-wide status survey for this species was conducted between 2013 and 2015 by Kuhajda et al. (2017) from TNACI. In a survey of 35 sites, Barrens Topminnows were found at 18 sites with evidence of successful reproduction (juvenile fish present) at 12 of these during the 3 year survey period. In 2015, the final year of the survey, topminnows were present at 17 sites, but evidence of successful reproduction was observed at 6 sites (Figure 2-2). The Barrens Topminnow is currently found in Warren, Coffee, Franklin, Cannon, and Dekalb Counties in Tennessee. The native populations from the Duck River drainage were extirpated soon after discovery, before fish could be kept in an ark population or genetic samples taken. Sites within the drainage are currently stocked with fish from Witty Creek MU and/or the Hickory Creek MU (USFWS, 2017). Barrens topminnow (Fundulus julisia), a freshwater fish species from Cannon, Coffee, Dekalb, and Warren Counties, Tennessee (USFWS, 2019).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Food Source

Juvenile: Microcrustaceans (USFWS, 2017)

Adult: Microcrustaceans and aquatic insects (USFWS, 2017)

Lifespan

Adult: 2-4 years (USFWS, 2017)

Reproduction Narrative

Adult: Lifecycle: The Barrens Topminnow is a protracted, fractional spawner (a few eggs at a time over a long period) that spawns over the course of the warm months (April to August), peaking from May to June (Figure 2-3). The colorful males perform an elaborate mating display, flaring their fins and chasing females in the clear water of the spring. The female will lay 1-6 eggs on filamentous algae or other submerged vegetation where they look like small air bubbles. Over the course of the breeding season, a female may lay more than 300 eggs over multiple spawning events. The adults typically live only 2 years due to high spawning mortality, though some survive to 4 years. The eggs hatch 8-10 days after spawning and the larvae stay close to vegetative cover. The young fish develop rapidly and within a few days, the larvae have transformed into juveniles (J.R. Shute, pers. comm.). Most fish mature and are ready to spawn within the first year, though some of the later spawned fish are in year 2 before they spawn (Rakes 1989, entire) (USFWS, 2017).

Habitat Narrative

Adult: This species is a spring specialist that is found in springhead pools and the slower areas of spring runs. Typical of members of the genus Fundulus, Barrens Topminnows prefer areas of slower current. These fish prefer areas with abundant aquatic vegetation such as filamentous algae (e.g. Clodophora and Pithophora), watercress (Nasturtium officinale) rushes (Juncus), pondweed (Potamogeton), and eelgrass (Valisneria) and will even utilize overhanging terrestrial plants and tree roots. Barrens Topminnows have only been found in areas with a large proportion of groundwater influence in the streams. Due to the groundwater influence of these habitats, the temperatures are relatively stable ranging from 15°C to 25°C (59- 77°F). The karst topography of the Barrens Plateau area allows for a number of spring systems to be present, though not all of these have been inhabited by the topminnow. In times of drought, if the discharge of the springs is severely reduced, Barrens Topminnows likely move downstream into more permanent water if suitable habitat is available (USFWS, 2017).

Dispersal/Migration

Population Information and Trends

Resiliency:

Because of the small number of sites that still have Barrens Topminnows (4), the high proportion that have mosquitofish present (4/5), the high proportion that would require continued stocking or rescue for continued existence (5/5), the bottlenecked genepool and the overall low connectivity in a small geographic area, the Hickory Creek MU is considered to have a low resilience to stochastic events. Because mosquitofish are in or adjacent to a high proportion of sites with mosquitofish in or adjacent to (63%), the low abundance of topminnows at half the sites, and two of the best sites are outside of the historic range of Witty Creek, this MU is considered to have a low resilience to stochastic events. The core of the Elk River ESU, Pond Spring, has been extirpated, and the two stocked sites that were still recently occupied, Merkle and Faris Springs, are likely extirpated as well or exist at extremely low population numbers meaning that the Elk River ESU may exist only as an ark population of a few hundred individuals (USFWS, 2017).

Representation:

Representation describes the ability of a species to adapt to changing environmental conditions over time and encompasses the “ecological and evolutionary patterns and processes that not only maintain but also generate species” (Shaffer and Stein 2000, p. 308). The Barrens Topminnow does not currently exhibit high representation due to the loss of the Duck River ESU and the reduction of the Elk River ESU to an ark population. We estimate that the Barrens Topminnow has low adaptive potential due to limited representation in two MUs within the same ESU. The genetic diversity of the species was found to be very low. Hurt et al. (2017) found only three mitochondrial haplotypes for the entire species, only one of which was represented in the entire Caney Fork ESU, which is extremely low variation compared to the 46 mitochondrial haplotypes found in a small portion of the range of the related Mummichog (Fundulus heteroclitus). Analysis of the nuclear genome found higher genetic variability, but also found evidence of genetic bottlenecking at Benedict Spring, the stocking source of the Hickory Creek MU, Pedigo, the stocking source for the Witty MU; and Pond Spring, the only native site in the Elk ESU (Hurt 2017). All sites are essentially isolated from one another by unsuitable habitat, mosquitofish, stream barriers, or drainage divides meaning that there is no opportunity for genetic exchange between sites, even within MUs, reducing the adaptive potential of the species as a whole (USFWS, 2017).

Redundancy:

Redundancy describes the ability of a species to withstand catastrophic events. It "guards against irreplaceable loss of representation" (Redford et al. 2011 p. 42; Tear et al. 2005 p. 841) and minimizes the effect of localized extirpation on the range-wide persistence of a species (Shaffer and Stein 2000, p. 308). It is characterized by having multiple, resilient populations distributed throughout the species ecological setting and across its range. For a species to exhibit greater redundancy the populations should not be completely isolated and immigration and emigration between populations should be achievable. The Barrens Topminnow is regarded to have low redundancy due to the loss of the Duck River populations, the likely extirpation of the Elk River ESU, the low resilience of the Caney Fork MUs, and the isolation of sites within the two Caney Fork MUs. The likelihood that a catastrophic event, such an extreme drought, chemical spill, or sudden invasion of mosquitofish, would cause the extirpation of a MU is fairly high and there is little or no opportunity for any eliminated sites from being recolonized naturally (USFWS, 2017).

Threats and Stressors

Stressor: Competition and Drought
Exposure:
Response:
Consequence:
Narrative: The main threats to the Barrens Topminnow are competition from introduced Western Mosquitofish, and the drying of springs during droughts.

Stressor: Predation
Exposure:
Response:
Consequence:
Narrative: The greatest threat to Barrens topminnow is predation from the western mosquitofish (Factor C), an invasive species native to portions of Tennessee west of the Barrens Plateau that preys upon young topminnows and harasses adults. Extirpation of Barrens topminnows has occurred consistently within 3 to 5 years of western mosquitofish invasion of a site, and the five sites where Barrens topminnows remain extant are the only sites not occupied by western mosquitofish. Predation upon Barrens topminnows by western mosquitofish (Factor C) is the primary driver of Barrens topminnow range curtailment and habitat modification (Factor A), as well as adverse demographic changes (Factor E). The presence of predatory western mosquitofish in most spring and stream systems of the Barrens Plateau has rendered otherwise suitable habitat for the Barrens topminnow uninhabitable. In addition to modification of habitat by a biological feature (invasive western mosquitofish), alteration of physical habitat features has occurred due to conversion of surrounding upland habitat to pasture, with concomitant removal of riparian vegetation and livestock accessing streams (USFWS, 2019).

Recovery

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SPECIES ACCOUNT: *Gambusia gaigei* (Big Bend gambusia)

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/11/1967; Southeast Region (R2) (USFWS, 2016)

Physical Description

A 2-inch fish (NatureServe, 2015). The species is a relatively plain, yellowish poeciliid whose faint lateral stripe is the most pronounced dark mark on the body. There is also a bar beneath the eye and a faint, dark chin bar (USFWS, 1984).

Taxonomy

A member of the family Poeciliidae (USFWS, 2012). Most authors place the Big Bend gambuaia in the Gambuaia nobilia species group (Hubbs and Springer 1957, Minckley 1962, Peden 1973); however, Rivas (1963) divided the 5 nobilia group Into the 5 nobilia and 5 senilis groups and placed G. gaigei in the latter (USFWS, 1984).

Historical Range

It historically occurred in two separate spring systems. The type locality of the species is from Boquillas Spring (also in Big Bend National Park), located about 1 mile (1.6 km) east of the springs at Rio Grande Village. This population was lost in the 1950s due to drying of the spring and subsequent invasion of western mosquitofish when water returned (Hubbs and Springer 1957, p. 305; Hubbs and Broderick 1963, pp. 47-48) (USFWS, 2012).

Current Range

The Big Bend gambusia is restricted to two constructed spring ponds (Spring 1 and Spring 4 refuge ponds) in the Rio Grande Village area of Big Bend National Park (USFWS, 2012). This species is restricted to springs in Big Bend National Park, Brewster County, Texas (Page and Burr 2011) NatureServe, 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Not available

Reproduction Narrative

Adult: This species is live-bearing. Females produce probably 5 - 8 broods per year (Hubbs and Mosier 1985) (NatureServe, 2015). Females likely only live for one year (Hubbs and Mosier 1985, p. 1063). Fecundity of the fish varies seasonally with reproduction occurring from 5 to 8 months a year. Broods were found to contain from 16 and up to 50 young in peak late spring periods, and interbrood intervals ranged from 24 to 29 days (Hubbs and Mosier 1985, pp. 1063-1064) (USFWS, 2012).

Environmental Specificity

Adult: Very narrow (inferred from USFWS, 2012)

Tolerance Ranges/Thresholds

Adult: Observations on water temperature tolerance are available from the Southwestern Native Aquatic Resources and Recovery Center (SNARRC) in Dexter, New Mexico. SNARRC staff estimate the temperature range tolerated by Big Bend gambusia held in refuge ponds at that facility is wide and includes lows of approximately 2–3° C (35.6–37.4° F) in winter and highs of approximately 33–34° C (91.4–93.2° F) in the summer (USFWS, 2023)

Habitat Narrative

Adult: Habitat includes vegetated, spring-fed sloughs and ponds (Page and Burr 2011); clear, warm-water springs, outflows, and marshes (Minckley et al. 1991). Survival apparently is best under stenothermal conditions. The species persists principally because of its ability to live in artificially ponded spring waters (Minckley and Deacon 1991) (NatureServe, 2015). The Big Bend gambusia is often found associated with dense stands of Chara spp. (submerged plant) and emergent vegetation in the refuge ponds (Hubbs et al. 2002, p. 82). Hubbs (2001, pp. 315-316) documented the average outflow temperatures of Spring 4 and Spring 1 as 34.9 ºC (95 ºF) and 33.1 ºC (92 ºF), respectively, with very low variability (USFWS, 2012).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available

Population Information and Trends

Population Trends:

Decline of 30-70% (NatureServe, 2015)

Number of Populations:

3 (NatureServe, 2015)

Population Size:

Several thousand; captive: 2,500 (USFWS, 2012)

Adaptability:

Low (inferred from USFWS, 2012 and NatureServe, 2015)

Population Narrative:

This species has experienced a long term decline of 30-70%. Once depleted to three individuals. At present, several thousand Big Bend gambusias inhabit two spring pool refugia and a spring-fed drainage ditch; smaller populations also occur in the presumed original habitat and the spring's outflow channel (Hubbs et al. 2002) (NatureServe, 2015). Some “several thousand” Big Bend gambusia occur in the small, isolated spring pond habitats at one location near Rio Grande Village in Big Bend National Park (Figures 1 and 2; Hubbs et al. 2002, p. 82). No population trends have been reported. A captive stock of about 2,500 individuals (USFWS 2010, p. 5) is maintained at Dexter NFHTC. Genetic bottlenecks (Johnson and Hubbs 1989, p. 311) have resulted in virtually no detectable genetic variation within the population (Echelle et al. 1989, pp. 221, 224; USFWS 2010, pp. 8-11). The lack of genetic variability, however, may pre-date the bottlenecking events in the 1950s and has not resulted in any apparent deleterious effects (Echelle et al. 1989, p. 224; Johnson and Hubbs 1989, p. 311) (USFWS, 2012). No research into or sampling designed to assess abundance, population trends, or demographics of the Big Bend gambusia has been conducted since the previous five-year review was approved in 2012. The monitoring that does occur provides a total count. Catch per unit effort may be quantified if adequate variables are recorded. Although qualitative, the monitoring data are informative, and the count data may be used to determine species persistence. In this document, we discuss several locations within Big Bend National Park. Figure 1 is provided for reference. Overall, the population status of the Big Bend gambusia is similar to that present as of the 2012 status review (USFWS, 2023)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Any substantial declines in the rate of flow from the springs would alter the habitat and could negatively affect the ecosystem that supports the Big Bend gambusia population. In the extreme case, if the flow from these springs ceased (due either to pump failure at Spring 1, which is supplied solely by a pump, or loss of natural flow from groundwater decline at Spring 4), then the species' habitat would be lost and the species would be extinct in the wild. Other springs in west Texas have been impacted by loss of spring flow due to groundwater pumping resulting in the elimination of the natural ecosystem and its fauna (for example, Comanche Springs and other springs near Fort Stockton, Hubbs 1990, p. 92; Scudday 1977, p. 516; Scudday 2003, pp. 136-137). Maintaining the water quality of the springs is an important component of the ecosystem for Big Bend gambusia habitat. Hubbs (2001, p. 312) documented the water chemistry of the waters in Big Bend gambusia habitat based on samples in 1999 (Table 1). Maintaining constant water temperatures is required to ensure that Big Bend gambusia are not outcompeted by western mosquitofish (see additional discussion below under section 2.3.2.5). Maintaining natural spring flows from the warm water aquifers allows these stenothermal conditions to persist. The natural habitat conditions in the springs where Big Bend gambusia occurs have been altered significantly over time (USFWS 1984, pp. 9-10). Before establishment of the Park (authorized in 1935), farm development destroyed Big Bend's most extensive wetlands at Rio Grande Village. Besides direct habitat alteration, one of the indirect effects of the adjacent public recreational facilities (campgrounds and picnic areas) is the potential for introduction of harmful species to the habitats of Big Bend gambusia (USFWS, 2012).

Stressor: Predation (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Predatory fishes, such as largemouth bass (Micropterus salmonides), green sunfish (Lepomis cyanellus), and channel catfish (Ictalurus punctatus), have periodically been found in and removed from the Spring 4 outflow pond (Hubbs et al. 2002, p. 82; USFWS 1984, p. 4). Other

potential predators include birds, crayfish, and frogs, but are not known to be a problem. As other threats occur, such as future habitat alteration or the introduction of other fishes into the refuge ponds, predation could be a confounding threat to the species and increases extinction probability (USFWS, 2012).

Stressor: Western mosquitofish (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Competition with western mosquitofish appears to be a substantial threat to the existence of the Big Bend gambusia. Big Bend gambusia seem to outcompete mosquitofish in warm stenothermal habitats (constant water temperatures) (Hubbs 2003, p. 130; Hubbs et al. 1986, p. 122); however, they have been replaced by mosquitofish on numerous occasions in nearby eurythermal (varying temperature) habitats (Hubbs et al. 2002, p. 82; USFWS 1984, p. 6). Western mosquitofish are common in many riverine, spring, and small stream habitats throughout the nearby Rio Grande drainage, making them readily available to invade any available aquatic habitat. Future invasion of the Springs 1 and 4 refuge ponds by western mosquitofish is a constant (imminent) and serious (high magnitude) threat to the continued existence of the Big Bend gambusia (USFWS, 2012).

Stressor: Nonnative species (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Non-native blue tilapia, green tree frogs (Hyla cinerea), and nutria (Myocastor coypus) occur sympatrically with the Big Bend gambusia. Blue tilapia and nutria could potentially cause extensive damage to the gambusia's habitat. The tilapia has invaded from the main-stem Rio Grande and has become common in the outflow pond of Spring 4 and the downstream beaver pond (Edwards 2010, p.1). Non-native tilapia (Oreochromis spp.) can cause extensive damage to natural ecosystems; some negative consequences on native species include competition for food and space, predation on the eggs and young of native fish, the spread of pathogens, and alteration of habitat including increased turbidity and reduction of vegetation (see Canonico et al. 2005 for review). Nutria cause severe environmental damage by burrowing into berms and stream banks (Drake 2005, p. 15). Nutria were noted to have removed emergent and riparian vegetation in the Spring 1 refuge pond, thereby reducing the amount of vegetative structure that is an important component of the physical habitat for Big Bend gambusia. Green tree frogs were discovered in the Rio Grande Village ponds and have become quite abundant (Leavitt and Fitzgerald 2009, p. 541). It is not known what effects the tree frogs may have on the gambusia (USFWS, 2012).

Stressor: Flooding (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Flooding from the Rio Grande or from the dry unnamed drainage from north of the springs (Figure 1) poses a constant threat to the species (USFWS 1984, p. 8). Extensive runoff could completely destroy the small pond habitats through sedimentation or erosion. Flooding from the Rio Grande could provide a vector for western mosquitofish (or other undesirable

species) to invade gambusia ponds and eliminate the fish from its habitat. In September 2008 the Rio Grande reached a record flood stage. The new Spring 4 refuge pond was overtopped and inundated with backwater from the river. As a result, several undesirable species of fish became established in the pond (USFWS, 2012).

Stressor: Climate change (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: Expected future warming from climate change could decrease overall availability of water recharging to aquifers in western Texas as climate change forecasts suggest warming and drying trends. The Big Bend gambusia may be highly sensitive to the effects of climate change based on the species' high vulnerability to any change in water temperature variation in spring outflows. An assortment of indirect effects of climate change is possible, such as changes to water quality, increases of non-native species, changes in disease susceptibility, and other factors (USFWS, 2012).

Stressor: Stochastic events (USFWS, 2012)
Exposure:
Response:
Consequence:
Narrative: The Big Bend gambusia may be susceptible to threats associated with small population size and impacts from stochastic events. Small population sizes can also act synergistically with other traits (such as being a habitat specialist and exhibiting a limited distribution, as in the Big Bend gambusia) to greatly increase risk of extinction (Davies et al. 2004, p. 270). Stochastic events from either environmental factors (random events such as severe weather) or demographic factors (random causes of births and deaths of individuals or unfavorable ratios of females and males) are also heightened threats to the Big Bend gambusia because of the limited range and small population sizes (Melbourne and Hastings 2008, p. 100). Finally, the small range of this fish does not provide any opportunity for natural recolonization if any of these factors resulted in a local extirpation event (Fagan et al. 2002, p. 3255) (USFWS, 2012).

Recovery

Reclassification Criteria:
The plan states that because of the extremely limited distribution and tenuous habitat, it may never be downlisted or delisted (USFWS 1984, p. 14) (USFWS, 2012).

Recovery Priority Number: 5 (USFWS, 2022)

Delisting Criteria:
The plan states that because of the extremely limited distribution and tenuous habitat, it may never be downlisted or delisted (USFWS 1984, p. 14) (USFWS, 2012).

Recovery Actions:

- Maintain and enhance the existing Big Bend gambu6ia population and Its habitat (USFWS, 1984).
- Establish Big Bend gambusia in suitable locations (USFWS, 1984).

- Maintain a captive population of Big Bend gambusia (USFWS, 1984).
- Produce information for public consumption (USFWS, 1984).
- Enforce Federal and State laws (USFWS, 1984).
- Most of the conservation actions for the Big Bend gambusia require the participation of the Park. Therefore, it is vital to maintain open dialogue and regular communications between the Service, Park, TPWD, and any other partners interested in conservation and recovery of the species (USFWS, 2012).
- Because of the precarious nature of the wild population of Big Bend gambusia, it is critical for its conservation to maintain a captive stock of the fish in a secure facility. Dexter NFHTC has maintained the species in captivity since 1974 and should continue to hold a population of the species (USFWS 2010, p. 12). Ideally this species should be maintained in more than one captive breeding facility (USFWS, 2012).
- Regular, routine monitoring (at least annually, preferably more often) of the Big Bend gambusia population in the Spring 1 and Spring 4 refuge ponds, as well as the beaver pond and Spring 4 outflow pond, should be carried out. (Recovery Task 1.2 [USFWS 1984, p. 19]) If funding becomes available, additional monitoring including fish health testing (annual or bi-annual) and/or genetics analysis (every 3-5 years) would be helpful to better assess the health of the wild population (USFWS, 2012).
- Water quality monitoring should be undertaken for the spring outflows and downstream to confirm maintenance of constant water temperatures. The Park has initiated monitoring of shallow groundwater levels near the springs and water level monitoring in the Santa Elena well. These data should continue to be collected and should be analyzed on an annual basis to evaluate any changes in groundwater levels over time and any potential effects of pumping from the well. Similarly, spring flow rates from Spring 4 should be monitored over time to detect any potential changes and determine if there is a relationship between pumping from the well and spring flow. This has been proposed by the Park (Wellman 2009, p. 1), but has yet to be implemented (Skiles 2010, p. 2) (USFWS, 2012).
- As recommended in the Recovery Plan (Service 1984, p. 23) and the Park's General Management Plan (NPS 2004, p. 62), the easternmost campsites at Rio Grande Village that are adjacent to Spring 4 refuge pond should be relocated to a greater distance away from the habitat of Big Bend gambusia (USFWS, 2012).
- Studies should be initiated to evaluate the vulnerability of Big Bend gambusia to the future impacts associated with climate change. For example, direct studies should be undertaken to determine thermal preferences and tolerances and effects of temperature on life history parameters that influence Big Bend gambusia's population dynamics. Studies should consider the effects of accelerating climate change on future groundwater levels and water temperatures at the spring outlets. (USFWS, 2012).
- The recovery plan should be updated to include objective and measurable criteria that take into consideration all of the threats to the species, including climate change. This is currently considered the lowest priority action because other conservation actions described in this 5-year review should be conducted first to accomplish tangible benefits for conservation of the species (USFWS, 2012).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The Big Bend gambusia recovery plan was last updated in 1984, and its associated recovery team last met in 2010. We recommend revising the recovery plan, if possible given workload constraints, and developing or enhancing relationships with appropriate partners, including governmental agencies and stakeholders, in order to carry out actions that will prevent the extinction of the species and promote its recovery. This will be a multi-year process. In the meantime, we recommend individual actions to be taken in coordination with the Park and other partners. Several currently occurring actions should continue. They include the Park's ongoing management of Spring 1 Refuge Pond and Hubbs Pond. SNARRC should continue to manage its Big Bend gambusia population and monitor the captive population for fish health and genetic concerns. These recommendations align with actions 1.2, 1.3, 2.1, 2.5, and 3.0 from the 1984 recovery plan. In addition to the ongoing actions, we also recommend revitalizing or initiating other actions to support the Big Bend gambusia and potentially recover the species to the point where it could be downlisted to Threatened, including but not limited to those listed below. 1) Reestablish regular and standardized monitoring of the Big Bend gambusia populations. Determine the frequency and type of monitoring of the species and its habitat needed to identify the presence of an imminent extinction risk. Identify entities who can reliably conduct monitoring over the long-term. Develop a written protocol guiding future monitoring. These recommendations align with action 1.2 from the 1984 recovery plan. 2) Enhance and restore Big Bend gambusia habitat. Evaluate the possibility of creating a habitable stream from the outflow of Spring 1 Refuge Pond. Evaluate the possibility of restoring natural flows to the outflow of Spring 4, and determine whether the western mosquitofish, blue tilapia, and other non-native species can be eliminated from or effectively controlled within this habitat. If aquatic habitat is created, stock with Big Bend gambusia and monitor their establishment. Determine explanatory mechanisms for the continued persistence of the Big Bend gambusia in the Beaver Pond. These recommendations align with actions 1.3, 2.1, 2.2, and 2.4 from the 1984 recovery plan. 3) Engage taxa experts to understand where and why the Big Bend gambusia is able to persist within the Beaver Pond, and determine the utility of stocking additional individuals in this location. This recommendation aligns with actions 1.1 and 2.1 from the 1984 recovery plan. 4) Develop formal plans to allow for continuity in species management over time and given turnover in staffing within USFWS and NPS. Develop captive stock and genetics management plans for the Big Bend gambusia at SNARRC that include target population abundance and clearly identify the purpose of the refuge population. Develop a catastrophic response plan for the Park populations of Big Bend gambusia. These recommendations align with actions 2.4 and 3.0 from the 1984 recovery plan. 5) Identify and implement improved strategies for managing aquatic emergent vegetation in Big Bend gambusia occupied and unoccupied habitat. This recommendation aligns with action 1.3 from the 1984 recovery plan. 6) Evaluate the potential for eDNA monitoring of the Big Bend gambusia habitat for both the Big Bend gambusia and predators and competitors such as the western mosquitofish and the blue tilapia. This recommendation aligns with actions 1.2 and 2.4 from the 1984 recovery plan. 7) Conduct genetic assessments of Big Bend gambusia populations from the Beaver Pond, Park refuge ponds, and SNARRC captive pond using techniques targeted to understand genetic variability among and within highly inbred populations. This recommendation aligns with actions 2.0 and 3.0 from the 1984 recovery plan (USFWS, 2023).

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SPECIES ACCOUNT: *Gambusia heterochir* (Clear Creek gambusia)

Species Taxonomic and Listing Information

Listing Status: Endangered; 03/11/1967; Southwest Region (R2) (USFWS, 2016)

Physical Description

A 2-inch fish (NatureServe, 2015). It is a stocky gambusia with a metallic sheen. Scattered terminal dark marks on some lateral or dorsal scales form distinctive crescentic marks. Females have a pronounced anal spot (USFWS, 1980).

Taxonomy

A member of the family Poeciliidae. Clear Creek gambusia is in the subgenus Arthrophallus, and a member of the nobilis species group (species group is a taxonomic grouping of species below the subgenus level), while western mosquitofish is in the same subgenus, but in the affinis species group (Rauchenberger 1989, p. 3) (USFWS, 2010).

Historical Range

It has never been known from more than the one isolated location in the headsprings area of Clear Creek within private land (Hubbs 1957, p. 8; Hubbs et al. 2008, p. 39). (USFWS, 2010). Historical range probably included most of the spring run (about 5 kilometers), to its confluence with the San Saba River (NatureServe, 2015).

Current Range

This species is restricted to a very small area of impounded headwaters (Wilkinson Springs) of Upper Clear Creek (San Saba River system) on the Clear Creek Ranch, 16 kilometers west of Menard, Menard County, central Texas (NatureServe, 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Clear Creek gambusia feed on small invertebrates, primarily the Clear Creek amphipod (Hyalella texana) (Hubbs 1971, p. 26) (USFWS, 2010).

Reproduction Narrative

Adult: Female may store sperm for several months, capable of producing about 50 young every 7 weeks; live bearing (Matthews and Moseley 1990) (NatureServe, 2015). The reproductive season for Clear Creek gambusia is February to October with highest fecundity occurring in June to August (Hubbs 1971, pp. 32, 34). Fecundity varies from 1 to 28 with an average of 9 embryos per brood (young fish birthed at the same time). Brood production is affected by light intensity with significantly fewer broods at lower light (Hubbs 1999, p. 748). Gambusia rarely live more than one year and may reach maturity as early as three months of age (Hubbs 1971, p. 14).

Females commonly outnumber males by nearly two to one (Hubbs 1971, p. 10) (USFWS, 2010).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2010)

Site Fidelity

Adult: High (inferred from USFWS, 2010; see dispersal/migration narrative)

Habitat Narrative

Adult: Habitat consists of springs and outflow streams with clear, clean water; this species prefers areas with dense aquatic vegetation (e.g., Ceratophyllum) and nearly constant temperatures throughout the year (USFWS 1982, Page and Burr 2011). Separation barriers include dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). Clear Creek gambusias are spring-adapted and limited to the flowing, clear, stenothermal (constant temperature of about 20.8 ºC, 69.4 ºF), near neutral pH (7.1) waters of the spring outflow (Hubbs 2001, p. 311) (USFWS, 2010).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (inferred from USFWS, 2010)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015). They remain close to the outflow of spring openings throughout their life (Hubbs 1957, p. 8) (USFWS, 2010).

Population Information and Trends

Population Trends:

Declining (USFWS, 2023)

Number of Populations:

1 (USFWS, 2023))

Population Size:

1000 - 10,000 individuals (NatureServe, 2015)

Population Narrative:

Historically, the area of occupancy likely was larger but declined after the habitat was modified. Total adult population size is unknown but presumably exceeds 1,000. This species is represented by one occurrence (NatureServe, 2015). The current range is limited to a small impounded spring head, encompassing an area of about 0.35 acres (1,400 square meters) (USFWS, 2010). Demographically, the Clear Creek gambusia population has declined severely since the last five-year status review. The risk of extinction has risen as a result. Since its discovery, Clear Creek gambusia have been found in the wild only at the headwaters of Clear Creek, in a pool created by a dam (U.S. Fish and Wildlife Service 2010b, p. 5). The source of these headwaters are a set of springs known as Wilkinson Springs and the size of the spring pool above the dam is about 0.35 acres (0.14 hectares) (U.S. Fish and Wildlife Service 2010b, p. 5). A captive population of Clear Creek gambusia is located at Inks Dam NFH (Texas Fish and Wildlife Conservation Office 2011, p. 24). Both the wild population and the captive population are in danger of extinction within the next several years (USFWS, 2023)

Threats and Stressors

Stressor: Stochastic events (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: The Clear Creek gambusia has an extremely limited range (Figure 1), with no known change since its discovery in the 1950s. This narrow range in combination with a short life span significantly increases the probability of extinction from either known or unknown threats (Johnson and Hubbs 1989, p. 316) or stochastic (random) events (Melbourne and Hastings 2008, p. 100). One future event that negatively impacts this population could easily result in the complete loss of the species (USFWS, 2010).

Stressor: Habitat modification (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Any substantial declines in the rate of flow from the springs would alter the habitat and could negatively affect the ecosystem that supports the Clear Creek gambusia population (Davis et al. 2004, p. 10). In the extreme case, if the flow from this spring ceased, then all of the species' habitat would be lost and the species would go extinct. Other springs in Texas have been impacted by loss of spring flow due to groundwater pumping (Anya and Jones 2009, pp. 48-49; TWDB 2006, p. 1-72). The potential for new large groundwater wells being developed to draw water from the contributing aquifer that supplies the spring flow is a threat to the Clear Creek gambusia's habitat. Agricultural chemicals for pesticides or fertilizers could create water quality problems, but no specific water quality problems are known from Clear Creek. The natural habitat conditions in Clear Creek were altered significantly by the construction of the four dams. At this time the only foreseeable local threats to Clear Creek gambusia (barring change of ownership) is the deterioration of the upper dam that may be allowing the migration of western mosquitofish into the upper pool (USFWS, 2010).

Stressor: Potential disease introduction (USFWS, 2010)
Exposure:
Response:

Consequence:
Narrative: It is possible that a disease or parasite could be introduced by other species moving into the area (such as birds or nutria) or inadvertently through human contact with the Clear Creek gambusia. The most important animal vectors for fish diseases are birds. Several species of fish-eating birds carry life stages of parasites ("grubs") that infest fish. There is also some evidence that birds may be able to transmit bacteria or viruses through their droppings. Birds may also drop fish that they have removed from one body of water into another (USFWS, 2010).

Stressor: Predation (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Predation does likely occur from the native predatory fish in Clear Creek (Hubbs 1971, p. 36), such as largemouth bass (Micropterus salmonides), green sunfish (Lepomis cyanellus), longear sunfish (Lepomis megalotis), redear sunfish (Lepomis microlophus), and yellow bullhead (Ictalurus natalis). Semi-aquatic snakes of the genus Nerodia and Thamnophis have also been documented to prey on Clear Creek gambusia (Hubbs 1971, p. 36). Avian predators like the belted kingfisher (Megaceryle alcyon), the great-blue heron (Ardea herodias), and the smaller green heron (Butorides virescens) all prey on small fishes in central Texas and could eat Clear Creek gambusia. Predation from these species is considered natural because these predators are native species and this threat alone is not considered substantial (USFWS, 2010).

Stressor: Hybridization (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: The synthesis of the genetic work in 2003 determined that, "from the standpoint of conservation there seems to be little need for concern regarding the genetic integrity of the wild population of G. heterochir" (Davis et al. 2006, p. 357). However, the study also concluded that this situation could change if the spring flows declined or if the dam were not maintained in a way that serves to separate the western mosquitofish downstream from the Clear Creek gambusia in the upper pool (Davis et al. 2006, pp. 357-358). Since the analysis of the fish in 2003, the upper dam has again deteriorated (Allan 2009, p. 1) and the levels of hybridization may now be higher as a result. This heightens the potential likelihood of this threat negatively affecting the population of Clear Creek gambusia (USFWS, 2010).

Stressor: Competition (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Competition for resources of food and space likely occur in the upper spring pool between Clear Creek gambusia and western mosquitofish (Hubbs 1971, p. 26). Both fish eat primarily insects and amphipods, with Clear Creek gambusia diet favoring amphipods and western mosquitofish diet favoring insects. This distinction is greatest during warmer months. During the winter however, western mosquitofish also consumed more amphipods and were in the greatest abundance in the upper pool when the dam did not prevent their migration (Hubbs 1971, p. 26). If western mosquitofish have easy access to migrate past the upper dam in the winter, they likely compete with Clear Creek gambusia for food and space resources, causing

lower population numbers of Clear Creek gambusia due to overwinter starvation (Hubbs 1971, p. 26) and increasing the probability of extinction of the remaining small population of Clear Creek gambusia in the upper pool (USFWS, 2010).

Stressor: Nonnative species (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Nutria (Myocastor coypus) is an aquatic, invasive mammal species that has had impacts on the integrity of the upper dam in the past by burrowing into the earthen structure. They were also noted to have decimated emergent and riparian vegetation along the creek in the 1950s (Hubbs 1971, p. 1). Nutria continue to occur in the area and could continue to be problematic for maintaining the upper dam, as they are a burrowing mammal that digs dens at the water level. This would allow immigration by western mosquitofish and have negative impacts on Clear Creek gambusia. Rainwater killifish (Lucania parva) was discovered in Clear Creek in the early 1980s (Edwards and Hubbs 1985, p. 15). Rainwater killifish does not appear to threaten Clear Creek gambusia, but it is unknown if it would present a problem if it became established in the upper pool (USFWS, 2010).

Stressor: Climate change (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Expected future warming from climate change could decrease overall availability of water recharging to aquifers in central and western Texas. If this were to occur, spring flows could decline directly because of decreases in recharge from declining precipitation, because the aquifer is dependent on rainfall precipitation for recharge (Anya and Jones 2009, p. 47). The spring habitat of the fish is dependent on groundwater levels that are directly influenced by precipitation patterns which could be altered as a result of climate change. Other indirect climate change effects to water quality, nonnative species, disease susceptibility, or other factors are possible (USFWS, 2010).

Recovery

Reclassification Criteria:
The 1982 Clear Creek Gambusia Recovery Plan does not list delisting or downlisting criteria (USFWS, 2010).

Recovery Priority Number: 2 (USFWS, 2023)

Delisting Criteria:
The 1982 Clear Creek Gambusia Recovery Plan does not list delisting or downlisting criteria (USFWS, 2010).

Recovery Actions:
- Not available
- The current landowner has been a cooperative partner for conservation of the Clear Creek gambusia by generously granting access to biologists in the past. Maintaining a positive,

collaborative relationship with the private landowner (and any future landowner) is paramount in conserving the Clear Creek gambusia, as with all conservation issues on private lands in Texas (Garrett 2003, p. 159). Personnel from the TPWD and the USFWS have had renewed positive contact with the landowner in 2009. The current landowner is open to assisting implementation of the conservation actions listed below (USFWS, 2010).

- The Clear Creek gambusia has never been in captivity other than in laboratory aquaria for research purposes. It is important to maintain a captive stock so that if a catastrophic event occurred that resulted in the loss of the wild population, a backup stock could be used to restore the species to the wild and prevent its extinction (Davis et al. 2004, pp. 11-12). A Genetic Reserve Population and Stock Management Plan is currently being drafted by the Dexter National Fish Hatchery and Technology Center in cooperation with Inks Dam National Fish Hatchery to direct the activities of establishing and maintaining a captive stock at Inks Dam National Fish Hatchery. The document will provide specific guidelines to preserve genetic identity, diversity, and viability for the population and ensure the program is in compliance with the USFWS's 2000 Policy Regarding Controlled Propagation (65 FR 56916). Funds were provided to the USFWS's Fisheries Program for this task through the USFWS's Preventing Extinction Initiative in FY2008 (USFWS, 2010).
- The small dam that maintains the upper pool and contains the majority of the Clear Creek gambusia is no longer functioning as an effective barrier to the western mosquitofish due to erosion. Water is now flowing through the dam. This condition likely allows the western mosquitofish to migrate through the dam in the winter and compete and hybridize with Clear Creek gambusia. The integrity of the upper pool dam should be restored to prevent the movement of western mosquitofish into the upper pool (Davis et al. 2006, p. 358) and maintain the stenothermal conditions there. Funds were provided to the USFWS's Fisheries Program to begin this task through the USFWS's Preventing Extinction Initiative in FY2009. This task is being initiated in 2010 and will be completed as soon as possible (USFWS, 2010).
- Regular, routine monitoring of the Clear Creek gambusia population (including periodic genetic analysis to assess the status of hybrids) in the upper pool should be carried out. The purpose is to establish a quantifiable baseline status of the species sufficient to document future trends in the population. Monitoring should include relative abundance of Clear Creek gambusia compared to western mosquitofish, proportion of hybrid fish based on genetic sampling, and presence of other fish species. Funds were provided to the USFWS's Fisheries Program for this task through the USFWS's Preventing Extinction initiative in FY2009. This task will be initiated in 2010 by staff from the San Marcos National Fish Hatchery and Technology Center and should be ongoing (USFWS, 2010).
- Water quality monitoring should be undertaken for the spring outflow into the upper headspring pool to obtain current water quality data (such as temperature, pH, dissolved oxygen, and salinity). Funds were provided to the USFWS's Fisheries Program for this task through the USFWS's Preventing Extinction initiative in FY2009. This task will be initiated in 2010 by staff from Inks Dam National Fish Hatchery and should be ongoing. Spring flow rates are only monitored by periodically measuring the stream discharge in Clear Creek at the highway crossing downstream. These data measure the aggregate flow of the creek, as there are likely other spring sources downstream for the headspring where the Clear Creek gambusia occurs. However, measuring only the discharge of Wilkinson Spring would be ideal but difficult to implement and probably not necessary. Measuring the creek flow should provide a reliable measure of the spring outflow. The USFWS should work with the USGS and Menard County UWD to determine if the flow at Clear Creek can be measured more frequently or, ideally, if a continuous gage could be installed (USFWS, 2010).

- The USFWS and TPWD should cooperate with the Menard County Underground Water District (District) to assist the District in making protection of spring flows from Clear Creek a high conservation priority. Information and plans should be exchanged and communications remain open. A common need in this area is for geologic and hydrologic studies to define recharge areas of groundwater in the county and groundwater movement into and through the county as it relates to Wilkinson Spring. The USFWS and TPWD should work with the USGS and Texas Water Development Board to look for opportunities to support these studies so that the District, and neighboring groundwater districts, can obtain the information needed to manage the aquifer resources to sustain spring flows from Clear Creek (USFWS, 2010).
- Studies should be initiated to evaluate the vulnerability of Clear Creek gambusia to the future impacts associated with climate change. For example, direct studies should be undertaken to determine thermal preferences and tolerances and effects of temperature on life history parameters that influence the Clear Creek gambusia's population dynamics. Studies should consider the effects of accelerating climate change on future groundwater levels and water temperatures at the spring outlets (USFWS, 2010).
- The recovery plan should be updated to include objective and measurable criteria that take into consideration all of the threats to the species, including climate change. This is currently considered the lowest priority action because other conservation actions described in this 5-year review should be conducted first to accomplish tangible benefits for conservation of the species (USFWS, 2010).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1) A critical step to take to prevent extinction of the Clear Creek gambusia is to repair the dam just below Wilkinson Springs on upper Clear Creek. If this cannot be accomplished, the species will likely become extinct, rendering all other actions moot. [Recovery Action 1.411] Because the species exists only on one parcel of private property, and there is no legal mechanism to allow the dam to be repaired, securing the cooperation of the landowner will be a necessary step in completing the dam repair action. 2) The current captive population of Clear Creek gambusia is in decline, likely as a consequence of genetic drift or inbreeding depression. Genetic analyses of the captive population are in progress to determine if and how to rescue the captive population. Any recommendations that result from this project should be implemented if possible given available resources. [Recovery Action 1.32] 3) Other future actions that may be pursued if the dam is repaired and resources are available include monitoring of the wild population, supplementing the captive population, captive propagation, monitoring water quality and quantity at Wilkinson Springs pool, restoring Clear Creek, and revising the species' recovery plan. [Recovery Actions 1.31, 1.32, and 1.42] (USFWS, 2023).

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SPECIES ACCOUNT: *Gambusia nobilis* (Pecos gambusia)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/13/1970; Southwest Region (R2) (USFWS, 2016)

Physical Description

A small fish, 4 cm long (NatureServe, 2015). Poeciliids are characterized by strong sexual dimorphism. The anal fin of males is modified into a gonopodium, an intromittent organ used in copulation. Gonopodial structures distinguish G. nobilis from the other poeciliids (i.e., Gambusia affinis and Gambusia geiseri) known to occur within its native range (USFWS, 1982).

Taxonomy

The Pecos gambusia, G. nobilis (Atheriniformes, Poeciliidae), was first described as Heteranxria nobilis by Baird and Girard in 1853 based on a syntypic series of specimens collected in 1853 from Leon and Comanche Springs, Pecos County, Texas, but later was assigned to the genus Gambusia by Girard (1859). Regan (1913) synonymized G. nobilis and g. senilis, but beginning with Hubbs (1926), both have been recognized as distinct and valid species (USFWS, 1982). Has hybridized with G. affinis at Blue Spring and Bitter Lakes National Wildlife Refuge, New Mexico (Sublette et al. 1990). Has hybridized also with introduced Gambusia geiseri (Minckley et al. 1991) (NatureServe, 2015).

Historical Range

Gambusia nobilis is endemic to the Pecos River basin in southeastern New Mexico and western Texas (Hubbs and Springer 1957, Behnke 1974) The species occurred at least as far south as Fort Stockton, Texas, and as far north as near Fort Sumner, New Mexico (USFWS, 1982).

Current Range

Range includes the Pecos River basin, Texas and New Mexico (Page and Burr 2011). It is restricted to sinkholes or springs and their outflow on the west side of the Pecos River in Chaves and Eddy counties. Natural populations are in two isolated gypsum sinkholes along with Sago and Dragonfly springs and their outflows, which combine to form the perennial portion of the Lost River (Bitter Creek drainage), all in Bitter Lake National Wildlife Refuge; other populations in the refuge are the result (in whole or in part) of introductions. An additional natural population occurs in Blue Spring, Eddy County, New Mexico. The species has been introduced in various areas of Salt Creek Wilderness Area and in artificial ponds at Living Desert State Park near Carlsbad, New Mexico. See Sublette et al. (1990). In Texas, this species inhabits the headwaters of Phantom Lake (Jeff Davis County); San Solomon, Giffin, and East Sandia springs (Reeves County); and Diamond Y Draw and Diamond Y Springs (Pecos County) (Hubbs et al. 2008) (NatureServe, 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Feeding occurs at the surface and in mid-water; diet includes insects (e.g., corixids and culicids) and amphipods, also some filamentous algae. Feeding occurs throughout the day, but primary feeding time correlates with insect activity at night (NatureServe, 2015). Hubbe et al. (1978) noted that G. nobilis fed on amphipods more than did other fishes in their study, but that a wide variety of food items indicated the species is an opportunistic feeder. Based on present patterns of occurrence and abundance, G. affinis seems to outcompete G. nobilis in relatively unstable habitat (USFWS, 1982).

Reproduction Narrative

Adult: A mean of 38 embryos were found in G. nobilis (USFWS, 1982).

Geographic or Habitat Restraints or Barriers

Adult: Hardness above 5000 mg/l CaCO3; dams, waterfalls, upland habitat (NatureServe, 2015); 822 - 1187 m elevation (USFWS, 1982)

Environmental Specificity

Adult: Narrow (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Habitat includes shallow margins of clear vegetated spring waters (pools and outflows) high in calcium carbonate, as well as more adverse gypsum sinkhole habitats (Lee et al. 1980, Page and Burr 2011). High salinities in gypsum sinkholes have precluded the success of most stockings in those habitats (Hendrickson and Brooks 1991). This fish is not tolerant of total hardness above 5000 mg/l CaCO3 (Bednarz 1979). Consistent habitat factors seem to be clear, clean water, stable flows, and fairly constant temperatures (Matthews and Moseley 1990). Abundance tends to be highest near spring sources (Minckley et al. 1991). Submerged cliffs and debris and aquatic vegetation are used for cover (Bednarz 1979). Separation barriers include dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). All populations occur between 822 m and 1187 m elevation (USFWS, 1982).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015).

Population Information and Trends

Population Trends:

Declining (NatureServe, 2015)

Species Trends:

Stable to < 30% decline (NatureServe, 2015)

Number of Populations:

~19 (inferred from NatureServe, 2015)

Population Size:

>1,000,000 individuals (NatureServe, 2015)

Population Narrative:

This species is less abundant now than in the past. Recent trend has not been reported, but range extent, area of occupancy, and number of subpopulations probably have been relatively stable or declining at a rate of less than 30 percent over 10 years or three generations. Total adult population size is very large. New Mexico population was estimated to total about 933,500 in 1979 (Bednarz 1979). Texas populations: 113,000 adults in vicinity of Balmorhea, 1 million adults in Leon Creek, Pecos County (Echelle and Echelle 1980). Yet Page and Burr (2011) stated that this species is "uncommon and localized." This species is represented by a small number of occurrences. It occurs in four main areas, two in New Mexico and two in Texas (Hubbs et al. 2002). These could be interpreted as four locations with respect to threats related to water availability. The area of occupancy is uncertain, but native populations likely occupy less than 20 square kilometers. Considering also introduced populations, area of occupancy probably is still less than or not much more than 20 square kilometers. Twelve populations are extant in the vicinity of Roswell. There is another natural population in Blue Spring NM, and it is found in six springs in TX (NatureServe, 2015).

Threats and Stressors

Stressor: Habitat loss and modification (NatureServe, 2015 and USFWS, 1982)
Exposure:
Response:
Consequence:
Narrative: The most pervasive threat is drying of springs due to lowering water tables (e.g., via groundwater pumping, which eliminated populations at Comanche and Tunis springs in western Texas, and which probably will occur at other sites in the near future) (Echelle et al. 1989) (NatureServe, 2015). The Pecos River mainstream has been influenced by man for more than 100 years, first through water withdrawals for irrigation and more recently through the construction of mainstream dams for irrigation and flood control. Presently, five major dams and at least three, lesser dams are on the mainstream Pecos River, and another dam (Brantley) is planned. These water uses have severely depleted natural flows in the river along major sections and caused drastic increases in-salinities in the remaining reaches (USFWS, 1982).

Stressor: Nonnative fish (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Other threats include predation by introduced fishes (especially in sites lacking aquatic vegetation or shallow water), and competition and possibly hybridization with other Gambusia species. A renovation of Diamond Y Draw in 1998 removed G. geiseri from that system (Hubbs et al. 2002). So far, hybridization has not had a significant impact. Introduced fishes (green sunfish) eliminated one transplanted population in Lake St. Francis and perhaps elsewhere on the Bitter Lakes NWR (Minckley et al. 1991) (NatureServe, 2015).

Recovery

Reclassification Criteria:
Monitoring of Pecos gambusia populations and habitats as described in Section 1.0 of the Stepdown Narrative (p. 22) indicate the four major populations are stable and secure (USFWS, 1982).

Delisting Criteria:
Reintroduction efforts described in Section 2.0 (p. 24) are accomplished (USFWS, 1982).

Recovery Actions:
- Maintenance and enhancement of existing Pecos gambusia populations and habitats (USFWS, 1982).
- Reestablish Pecos gambusia within portions of its historic range (USFWS, 1982).
- Disseminate information about Pecos gambusia (USFWS, 1982).
- Hold and propagate Pecos gambusia in a hatchery (USFWS, 1982).
- New Recovery Priority Number: 11 (USFWS, 2018),
- During August 1972 and April and May 1973, the Bitter Lake National Wildlife Refuge in New Mexico transplanted G. nobilis from various waters near the north end of the refuge into 20 separate localities within the same refuge and within the Salt Creek Wilderness Area. As a result of these transplants, new populations were established in Sinkholes 2 and 10 and in Ink Pot, and an existing population in Sinkhole 20 was supplemented. The other 16 transplants failed. Additional transplants of G. nobilis were made within the Bitter Lake National Wildlife Refuge during July and August 1981. However, adequate time has not elapsed to determine if these represent viable stocks (UFWS, 1982).
- U.S. Fish and Wildlife Service personnel at Dexter National Fish Hatchery, Dexter, New Mexico, successfully raised G. nobilis in captivity. In addition, personnel from the New Mexico Department of Game and Fish, in cooperation with personnel from the New Mexico Environmental Improvement Division, successfully raised G. nobilis in an abandoned sewer treatment facility at Carlsbad, New Mexico. These stocks have been terminated, but their success demonstrates the feasibility of this approach (USFWS, 1982).
- The Texas Parks and Wildlife Department constructed a native fish fauna refugium at Balmorhea State Recreation Area. Although the refugium was constructed principally for the conservation of Cyprinodon elegana, it is being considered for introduction of G. nobilis. G. nobilis is protected against human incursions at Phantom Lake Spring because the Federal land on which the spring is located is nearly surrounded by private land with restricted access (USFWS, 1982).
- Northern Natural Gas Company, Exxon Company, and others operate in the vicinity of Leon Creek and are cautious to avoid adverse impacts on the area. The Trans-Pecos Soil and Water Conservation District, in cooperation with the Soil Conservation Service, constructed a protective dike around Diamond-Y Spring to insure that an oil spill will not reach this habitat (USFWS, 1982).
- In 1976, a management effort was undertaken in Leon Creek to preserve Cyprinodon bovinus (Hubbs 1980). Following renovation efforts, care was exercised to return C. bovinus and G. nobilis to the lower section of Leon Creek (Hubbs et-al. 1978). The endangered status afforded G. nobilis by the Endangered Species Act of 1973 is a major deterrent to taking of

G. nobilis. Section 7 of the Act directs Federal agencies to institute / conservation and restoration programs for endangered species. The Act also specifically forbids activities of Federal agencies that might jeopardize the survival of endangered species or alter critical habitat. Leon Creek was designated as critical habitat for C. bovinus in 1980. This action also provides protection for G. nobilis habitat (USFWS, 1982).

- Landowners provide additional protection to various populations of G. nobilis in New Mexico and Texas because of limited access and responsible protective measures. The populations on Bitter Lake National Wildlife Refuge and Salt Creek Wilderness Area are located on Federal property. Access to these areas is restricted. The refuge manager is aware of the needs of the species and is alert to help prevent potentially hazardous situations. Hatch and Conway (1980) developed a management plan for G. nobilis on the refuge (USFWS, 1982).
- RECOMMENDATIONS FOR FUTURE ACTIONS The following recommendations are provided to direct actions in the coming years to further the recovery of the Pecos gambusia. These recommendations are based on the species recovery plan (Service 1983, entire) and potential new threats to the species not originally considered under the plan, such as extensive oil and gas development within the San Solomon Springs system, the invasive red-rim melania and associated gill parasite, and climate change. The recommended actions are to: I. Cooperate with Federal, State, and NGO landowners to protect habitat While Pecos gambusia populations located on private property (i.e., Blue Spring and Giffin Spring) are important to the long-term conservation and recovery of the species, most of the conservation actions for the Pecos gambusia require the participation of the Service, BOR, TPWD, and TNC. Therefore, it is vital to maintain open dialogue and regular communications between these federal, state, and NGO landowners interested in conservation and recovery of the species. II. Monitor water quantity and quality Long-term water quality and quantity monitoring should be undertaken for the spring outflows and downstream spring dependent habitats of the Pecos gambusia throughout its current range. Some limited spring flow and water quality monitoring is currently underway by TPWD at San Solomon Spring, and by other researchers at Diamond Y Spring and East Sandia Spring. These efforts should continue and be expanded to other Pecos gambusia locations to provide data on long-term changes in spring flow rates, aquifer levels and flow paths, temperatures, water chemistry parameters, contaminants, and other biotic and abiotic factors that may have long-term impacts to the species or habitats. This is especially important given the significant future oil and gas development activities in and around the San Solomon Spring system that are expected to occur over the next 20 years. (Recovery Plan Task 1.22 [Service 1983, p. 22]) III. Monitor fish populations and habitat Monitoring of Pecos gambusia populations should be undertaken on a regular basis to establish baseline data on status, abundance, and trends of the species in those occupied habitats. Monitoring should also cover areas that are lacking in recent abundance estimates, especially those areas where recent habitat restoration/improvement efforts have occurred (i.e., San Solomon and Phantom Lake springs), or recent introductions of new populations into habitats have occurred, such as at BLNWR. Coincident with population monitoring, monitoring of habitat conditions should occur. Habitat conditions such as potential water quality or quantity changes (decreases in amount of available habitat, potential contaminants), changes in abundance and type of aquatic or shoreline vegetation, and any other indicators of change in habitat quality should be monitored. Special attention should be made to monitor pump system integrity and function at Phantom Lake Spring. [Recovery Plan Task 1.11 (Service 1983, p. 22)] IV. Enhance existing habitats The existing habitat of the species should be

improved when opportunities arise, only after evaluating the impacts on other endangered species within the system. This includes monitoring restoration efforts at San Solomon Spring and Phantom Lake Spring, and focusing on improving habitat in the remainder of the areas in New Mexico and Texas known to be occupied by the species. [Recovery Plan Task 1.23 (Service 1983, p. 23)] V. Monitor genetic status of populations Hybridization and introgression of western mosquitofish and largespring gambusia has the potential to significantly impact existing Pecos gambusia populations. Periodic monitoring of genetic status should be conducted to establish a quantifiable baseline status of the species sufficient to document future trends in the populations. Monitoring should include relative abundance of Pecos gambusia compared to western mosquitofish and largespring gambusia, and the proportion of hybrid fish based on genetic sampling. [Recovery Task 1.5 (Service 1983, p. 23)] VI. Monitor for effects of the gill parasite Pecos gambusia should be routinely inspected for presence of gill parasites in all populations. The host snail and parasites should be counted to determine trends in parasite load and host snail abundances through time. Any observations of adverse effects of the gill parasites on individual Pecos gambusia should be recorded. VII. Evaluate the need to establish a captive refugia stock Because of the small number of existing populations currently known in New Mexico and Texas, the establishment of a captive refugia stock of the species to protect against losses of populations in the wild, maintain genetic diversity, and have fish available for reintroduction into historical habitats or after a catastrophic loss of a population, or to supplement existing populations. (Recovery Plan Task 4.0 [Service 1983, p. 26]) VIII. Conduct climate change vulnerability analysis Studies should be initiated to evaluate the vulnerability of Pecos gambusia to the future impacts associated with climate change. For example, direct studies should be undertaken to determine thermal preferences, tolerances and effects of temperature on life history parameters that influence Pecos gambusia population dynamics. Studies should consider the effects of accelerating climate change on future groundwater levels and water temperatures at spring outlets. IX. Update the recovery plan The recovery plan should be updated to include objective and measurable criteria that take into consideration all of the threats to the species, including climate change. This is currently considered the lowest priority action because other conservation actions described in this 5-year review should be conducted first to accomplish tangible benefits for conservation of the species (USFWS, 2018).

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SPECIES ACCOUNT: *Gasterosteus aculeatus williamsoni* (Unarmored threespine stickleback)

Species Taxonomic and Listing Information

Commonly-used Acronym: UTS

Listing Status: Endangered; October 13, 1970 (35 FR 16047).

Physical Description

The unarmored threespine stickleback (Gasterosteus aculeatus williamsoni) is a small, scaleless, freshwater fish of up to 5 centimeters (cm) (2 inches [in.]) standard length (i.e., the distance from the tip of the snout or lower jaw to the end of the vertebral column) (USFWS 2009). The dorsal fin consists of two isolated spines anteriorly (toward the head), with a third smaller spine at the front edge of the more posterior (toward its rear or tail), soft-rayed portion of the fin. The most striking features, however, are the unusual pelvic girdle, with a denticulated spine on either side and large, lateral bony plates of varying number (zero to about 35). Threespine sticklebacks also are known for the brilliant male nuptial coloration of red on the head, which sometimes extends back to the origin of the anal fin; breeding females tend to be pale-green-to-brown dorsally and silver ventrally (USFWS 1985).

Taxonomy

The unarmored threespine stickleback was first described by Girard (1854) based on a collection from "Williamson's Pass," known today as Soledad Canyon, Los Angeles County, California. There are three subspecies of threespine stickleback recognized on the Pacific Coast of North America: (1) fully plated threespine stickleback (Gasterosteus aculeatus aculeatus); (2) low or partially plated threespine stickleback (G. a. microcephalus); and (3) unplated or unarmored threespine stickleback (G. a. williamsoni). Threespine stickleback taxonomy can be problematic as a result of their wide distribution, anadromous nature, and ability to establish nonanadromous freshwater populations. The unarmored threespine stickleback is distinguished from other sticklebacks by the number of lateral plates, provided that 10 to 15 morphologically mature specimens are available. The unarmored threespine stickleback generally have an average of 0.06 to 0.55 lateral plate per individual, and partially armored threespine sticklebacks have an average of more than six lateral plates per individual. Additional characters used to distinguish the unarmored threespine stickleback from other threespine sticklebacks include short dorsal and pelvic spines, rounded pectoral and caudal fins, a less streamlined body, reduced denticulation of the spines, and reduced size of the ascending branch of the pelvic girdle (USFWS 2009).

Historical Range

At the time of listing, there were no abundance data for this subspecies, and unarmored threespine sticklebacks were only known to occur in the upper reaches of the Santa Clara River, including Soledad Canyon. They were previously found in low-gradient portions of the Los Angeles, San Gabriel, and Santa Ana rivers, and from a few localities in Santa Barbara County, but have been extirpated from these areas as a result of the effects of urbanization (e.g., dewatering of streams, habitat alteration, introduction of exotic predators, and pollution). In 1917, unarmored threespine sticklebacks were reported to be abundant throughout the Los

Angeles Basin, but by 1942 they were no longer found there and were believed to be extinct (USFWS 2009).

Current Range

The unarmored threespine stickleback is currently restricted to three areas: the upper Santa Clara River (Soledad Canyon and the Del Valle area) and its tributaries (San Francisquito Canyon) in Los Angeles County; San Antonio Creek on Vandenberg Air Force Base in Santa Barbara County; and the Shay Creek vicinity (which includes Shay Pond, Sugarloaf Pond, Juniper Springs, Motorcycle Pond, Shay Creek, Wiebe Pond, and Baldwin Lake), in San Bernardino County. San Felipe Creek in San Diego County is another area that may support the unarmored threespine stickleback; however, its current status is unknown (NatureServe 2015; USFWS 2009).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: The unarmored threespine stickleback is an opportunistic insectivore that feeds primarily on insects, small crustaceans, and snails; and, to a lesser degree, on flatworms, nematodes, and terrestrial insects. Most of the prey are benthic, but some are nectonic or terrestrial. Primary food items in San Antonio Creek consist of chironomid larvae, amphipods, and ostracods, with consumption of these foods correlated with their abundance in their habitat (USFWS 1985).Competition from invasive species, notably mosquitofish (Gambusia affinis), can reduce availability of food (USFWS 2009).

Reproduction Narrative

Adult: Reproductive activity of the unarmored threespine stickleback generally occurs in pools and in sheltered areas of streams, but may take place in weed-choked margins of streams. Pools up to 100 m (328 ft.) in length and about 40 cm (15 in.) or greater in depth are optimal habitat for reproduction, provided aquatic vegetation is present. Unarmored threespine sticklebacks breed throughout the year, with an increase in reproductive activity in the spring, peaking in March, and with the least breeding activity occurring from October to January (USFWS 1985; USFWS 2009; NatureServe 2015).The male builds a nest of fine plant debris and algal strands and courts all females that enter his territory; a single nest may contain the eggs of several females. Young unarmored threespine sticklebacks hatch in a nest from eggs that have been brooded for several days by the adult male, who fans the eggs and guards the nest and surrounding territory from possible predators. This parental care is essential for successful reproduction (USFWS 1985). Young unarmored threespine sticklebacks remain in the nest after hatching, although the length of time they remain in the nest is unknown. The smallest specimens of the unarmored threespine stickleback captured outside of a nest are approximately 10 mm (0.40 in.) standard length (USFWS 2009). Individuals are believed to live for only 1 year (USFWS 1985; USFWS 2009; NatureServe 2015).Unarmored threespine sticklebacks are not distributed uniformly throughout the rivers and streams in which they occur, and breeding habitat is patchily distributed. The nature of breeding habitat is dynamic and may shift in structure and specific location from year to year, depending on seasonal rainfall and storm cycles (USFWS 2009).

Geographic or Habitat Restraints or Barriers

Adult: Dam lacking a suitable fishway; high waterfall; and upland habitat (NatureServe 2015).

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Narrow/specialist.

Habitat Narrative

Adult: Unarmored threespine sticklebacks spend all of their life in slow-moving or standing freshwater streams and pools with vegetative cover. Young unarmored threespine sticklebacks are typically found at the shallow edges of streams with sand or mud substrate, water temperatures less than 24 °C (75 degrees °F), and abundant aquatic vegetation. The larger juveniles and sub-adults (less than 20 mm [0.79 in.] standard length) also tend to be found in the protection of vegetation, in slow-moving or standing water. Adults (3 to 5 cm [1 to 2 in.] standard length or more) are found in all areas of the stream.In places where water is moving rapidly, they tend to be found behind obstructions, or at the edge of the stream, especially under the edge of algal (Cladophora sp.) mats (USFWS 1985; USFWS 2009). In more open reaches, algal mats or barriers (e.g., sand bars, floating vegetation, low-flow road crossings) may provide refuge for the species. Lack of turbidity is a requirement (NatureServe 2015). Unarmored threespine sticklebacks are not distributed uniformly throughout the rivers and streams in which they occur, and breeding habitat is patchily distributed (USFWS 2009). Unarmored threespine sticklebacks require a physical or geographic barrier to prevent predators or introduction of the nonlisted and more prevalent, low or partially plated threespine stickleback (G. a. microcephalus) (NatureServe 2015; USFWS 1985).

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Data on dispersal and other movements generally are not available (NatureServe 2015).

Dispersal/Migration Narrative

Adult: Data on dispersal and other movements generally are not available (NatureServe 2015).

Population Information and Trends

Population Trends:

Relatively stable (less than or equal to 10 percent change); however, only a few populations remain, all of which are vulnerable (NatureServe 2015).

Species Trends:

Stable

Number of Populations:

The unarmored threespine stickleback is currently restricted to three areas; a fourth area may support the species (USFWS 2009).

Population Size:

Relatively abundant where found (NatureServe 2015).

Resistance to Disease:

The degree to which parasites and pathogens affect unarmored threespine stickleback survival and productivity is unknown. Disease was not considered a threat at the time of listing; however, parasites and disease have been detected among unarmored threespine stickleback populations (USFWS 2009).

Additional Population-level Information:

No range-wide, long-term monitoring program is currently being conducted for the unarmored threespine stickleback, and data on population dynamics are limited. Despite the availability of survey methods that can estimate constant variability in local abundance (i.e., annual and seasonal changes in distribution and abundance hamper efforts to estimate population size for this short-lived species), estimates of population size are generally lacking due to minimal survey efforts. The unarmored threespine stickleback populations also vary with between-year changes in environmental conditions, such as drought (USFWS 2009).

Population Narrative:

The population of the unarmored threespine stickleback is considered to be relatively stable (less than or equal to 10 percent change); however, only three recognized populations remain, all of which are vulnerable (NatureServe 2015). The unarmored threespine stickleback is currently restricted to three areas, and a fourth area may support the species. Locations where populations are currently known or believed to occur include the upper Santa Clara River (Soledad Canyon and the Del Valle area) and its tributaries (San Francisquito Canyon) in Los Angeles County; San Antonio Creek on Vandenberg Air Force Base in Santa Barbara County; and the Shay Creek vicinity (which includes Shay Pond, Sugarloaf Pond, Juniper Springs, Motorcycle Pond, Shay Creek, Wiebe Pond, and Baldwin Lake), in San Bernardino County. San Felipe Creek in San Diego County is another area that may support the unarmored threespine stickleback; however, its current status is unknown (NatureServe 2015; USFWS 2009).The degree to which parasites and pathogens affect unarmored threespine stickleback survival and productivity is unknown. Disease was not considered a threat at the time of listing; however, parasites and disease have been detected among unarmored threespine stickleback populations (USFWS 2009). Unarmored threespine sticklebacks are reported to be relatively abundant in streams where they are found (NatureServe 2015). No range-wide, long-term monitoring program is currently being conducted for the unarmored threespine stickleback, and data on population dynamics are limited. Despite the availability of survey methods that can estimate constant variability in local abundance (i.e., annual and seasonal changes in distribution and abundance hamper efforts to estimate population size for this short-lived species), estimates of population size are generally lacking due to minimal survey efforts. The unarmored threespine stickleback populations also vary with between-year changes in environmental conditions, such as drought (USFWS 2009).

Threats and Stressors

Stressor: Stream channelization
Exposure: Destruction or manipulation of suitable habitat.
Response: Several, including loss of cover, food source, breeding sites, and increased predation.
Consequence: Decreased population numbers.
Narrative: Stream channelization increases water velocity in pools, eliminates shallow backwaters, reduces aquatic vegetation, and increases peak flows during floods. Stream channelization can reduce or eliminate the side channels and back-water pool habitat used by unarmored threespine sticklebacks, and increase flow velocity, which may reduce or eliminate the substrate needed for nests (USFWS 1985; USFWS 2009).

Stressor: Urbanization
Exposure: Increase in pollution, and in competition from nonnative species.
Response: Disappearance of suitable aquatic habitat for unarmored threespine sticklebacks.
Consequence: Decreased population numbers.
Narrative: Urbanization decreases water quality through an increase in runoff, siltation, nutrients, pesticides, and other pollutants in the river. Urban and commercial development adjacent to or upstream of a water course can lead to the loss of freshwater fish and an increase in nonnative species. Nonpoint-source pollution and habitat alteration often result from urbanization. One of these sources of pollutants is stormwater run-off, which is the byproduct of the construction of roadways or structures that reduce the permeability of urban watersheds. Stormwater run-off resulting from urbanization conveys large amounts of organic matter; pesticides; and fertilizers; heavy metals, such as hydrocarbons; and other debris into streams and wetlands (USFWS 2009).

Stressor: Introduction of predators
Exposure: Increased predations.
Response: Increase in selective pressure may result in remove individuals, or restriction to habitats to which unarmored threespine sticklebacks are poorly adapted.
Consequence: Random or selective removal may eventually result in the extirpation of a population or loss of individuals with different plate counts.
Narrative: Nonnative species have been a major factor in the decline of the unarmored threespine stickleback. Introduction of predators and competitors may adversely affect the unarmored threespine stickleback by removing individuals or restricting them to habitats that the predators cannot enter. Some predators randomly prey on the unarmored threespine stickleback, while others may select the unarmored threespine stickleback based on appearance; previous studies have found that predators remove sticklebacks with different plate counts at different rates. This can produce a shift in the frequency of individuals with different numbers of plates, which may result in the unarmored threespine stickleback more closely resembling the partially armored threespine stickleback. Introduced aquatic vertebrates and invertebrates are predators on one or more of the life stages of the unarmored threespine stickleback. These include African clawed frogs (Xenopus laevis), bullfrogs (Rana catesbeiana), red swamp crayfish

(Procambarus clarkii), signal crayfish (Pacifastacus leniusculus), and various species of fishes, especially bass (Micropterus spp.), catfish (Ictalurus spp.), sunfish (Lepomis spp.), and mosquito fish (USFWS 2009).

Stressor: Introgression (hybridization between species, subspecies, or populations of organisms).
Exposure: Stream channelization that allows predators to reach unarmored threespine sticklebacks, or introduction of partially or fully armored threespine sticklebacks.
Response: Increased predation or hybridization.
Consequence: Potential extirpation of population or loss of "unarmored" individuals.
Narrative: Introgression results from hybridization between groups (species, subspecies, or populations) of organisms (i.e., the flow of genes from members of one of these groups into members of another group through cross-breeding). The result of introgression is that the group receiving intensive gene flow will come to resemble the source group. Increased gene flow to unarmored threespine sticklebacks may be caused by stream channelization, releases of water containing partially or fully armored threespine sticklebacks, or the introduction of partially or fully plated threespine sticklebacks into the habitat of unarmored threespine sticklebacks. The latter may occur when partially or fully plated threespine sticklebacks are inadvertently introduced into the unarmored threespine stickleback habitat along with game fishes. Introductions such as this by private parties for recreation (e.g., trout and bass fishing) becomes increasingly likely as urbanization occurs in the upper Santa Clara River Basin. Introgression can be a cause for concern for an imperiled species, even leading to extinction (USFWS 2009).

Stressor: Agricultural impacts
Exposure: Varied (loss of habitat, pollution, etc.).
Response: Loss of available habitat, and reduced growth.
Consequence: Decreased population numbers.
Narrative: Possible impacts of agriculture are varied, depending on the type of agriculture and techniques used. Increased discharge of silt from agricultural activities can cause habitat destruction by covering the substrate of pools and backwater channels with fine sediment or completely filling them in. Increased siltation may be caused by overgrazing or by irrigation. Eutrophication is the excessive growth of aquatic vegetation resulting from the input of nutrients, particularly phosphate and nitrate. Furthermore, the addition of phosphates to laundry detergents has added a heavy phosphate burden to natural water systems. Discharge of these nutrients into the unarmored threespine stickleback habitat is increased by urbanization as well as agriculture. Water quality in the Santa Clara River drainage, including its tributaries; San Antonio Creek; and Shay Creek are compromised by excess nutrient loads in runoff from areas that support agricultural activities (USFWS 2009).

Stressor: Oxygen reduction
Exposure: High levels of aquatic vegetation or organic matter.
Response: Reduced growth or fish kill.
Consequence: Death of individuals.
Narrative: Oxygen reduction occurs when the total demand for oxygen by biological and chemical processes exceeds the oxygen input from aeration and dissolved oxygen levels required to maintain aquatic life. Oxygen reduction is usually associated with abundant growth of rooted vegetation, heavy algal blooms, or high concentration of organic matter (e.g., fertilizers, sewage, or livestock feces), which results in eutrophication from untreated or partly treated sewage. Unarmored threespine sticklebacks have a moderate tolerance to oxygen reduction (down to 2.0

parts per million [ppm]). As oxygen concentration approaches 2.0 ppm, the amount of energy that unarmored threespine sticklebacks use for respiration increases, thereby detracting from somatic growth, reproduction, and activity. Thus, sub-lethal reductions of dissolved oxygen may reduce growth and reproduction of the unarmored threespine stickleback, possibly placing them at a competitive disadvantage with sympatric fishes. Eutrophication therefore could eliminate the unarmored threespine stickleback directly by reducing dissolved oxygen to lethal levels, or indirectly by reducing dissolved oxygen to detrimental levels (USFWS 1985; USFWS 2009).

Stressor: Groundwater removal
Exposure: Groundwater removal.
Response: Increased water temperature, and changes in hydrology.
Consequence: Reduction in population, extirpation.
Narrative: Excessive groundwater removal can, in some cases, result in the complete drying of a stream reach or pond, especially during drought conditions. Groundwater removal can also result in increased water temperatures. As the volume and flow of water declines, pools become shallower and water temperature increases. Unarmored threespine sticklebacks have a moderate tolerance (a critical thermal maximum of 30.5 °C [86.9 degrees °F] when acclimated at 8 °C [46.4 degrees °F] and a critical thermal maximum of 34.6 °C [94.3 degrees °F] when acclimated at 22.7 °C [72.8 degrees °F]) (USFWS 1985; USFWS 2009).

Stressor: Transpiration and the effects of giant reed (Arundo donax)
Exposure: Presence of giant reed.
Response: Lowers groundwater table, decreases surface water levels, increases potential for wildfire, and reduces diversity.
Consequence: Reduction in population and fitness.
Narrative: In plants, approximately 99 percent of the water taken in by the roots is released by the plant into the air as water vapor. Giant reed (Arundo donax) threatens river ecosystems by affecting natural river processes, such as lowering groundwater tables, decreasing surface water levels in streams, increasing the potential for wild fires, and reducing animal and plant diversity. Giant reed may decrease surface-water levels by the transpiration process (USFWS 2009).

Stressor: Off-highway vehicles (OHV)
Exposure: Destruction or manipulation of suitable habitat.
Response: Several, including loss of cover, food source, breeding sites, and increased predation.
Consequence: Injury or mortality, reduced fitness.
Narrative: The ecological effects of OHV use can result in vegetation destruction, increased erosion, and increased flow. Unmanaged, OHV use can damage riparian vegetation, increase siltation in pools, compact soils, disturb the water in stream channels, and crush unarmored threespine sticklebacks. The unarmored threespine stickleback habitat may be adversely impacted by OHV activities that destroy forage and breeding locations. OHVs may also crush individual unarmored threespine sticklebacks or their nests (USFWS 2009).

Stressor: Drinkwater reservoir
Exposure:
Response:
Consequence:
Narrative: Habitat for the unarmored threespine stickleback exists in San Francisquito Creek at its confluence with Drinkwater Canyon in the Angeles National Forest. This habitat is

approximately 100 m (328 ft.) long during the summer, but extends to a length of about 1.5 kilometers (0.93 mile) in the winter. A reservoir in Drinkwater Canyon releases water that maintains the small amount of unarmored threespine stickleback habitat in San Francisquito Canyon. The Los Angeles Department of Water and Power releases 28 liters (1 cubic foot) per second of water throughout the year to satisfy the water rights of private property owners downstream of the reservoir; however, the flow is temporarily terminated when the discharge pipes at the reservoir are cleaned. Without careful management and timing of discharges, any remaining unarmored threespine sticklebacks in upper San Francisquito Canyon could be lost (USFWS 1985; USFWS 2009).

Stressor: Toxic spills and discharges
Exposure: Destruction or manipulation of suitable habitat.
Response: Reduced growth, or fish kill.
Consequence: Potential extirpation of population.
Narrative: The floodplain of the Santa Clara River in Soledad Canyon is crossed by the Southern Pacific Railroad tracks, Soledad Canyon Road, and the access roads for several commercial campgrounds. The possibility exists that a toxic chemical spill from private land or a railroad or highway accident could destroy the entire Soledad Canyon population of the unarmored threespine stickleback. Although the unarmored threespine stickleback may be seasonally abundant in most years, its restricted distribution renders it vulnerable to catastrophic extirpation from an accidental spill (USFWS 2009).

Stressor: Addition of water
Exposure: Varied (loss of habitat, predation, etc.).
Response: Loss of habitat, and increased predation.
Consequence: Potential extirpation of population, or loss of "unarmored" individuals.
Narrative: The addition of water to drainages in southern California can be beneficial or harmful to the unarmored threespine stickleback, depending on the timing, amount, and contents of the water. Both the increase in size and productivity of habitat that may occur as a result of additional water releases would tend to increase the population of the unarmored threespine stickleback; however, if too much water is released, increased flows could wash out pools and side channels or wash away the debris that help maintain flows at an appropriate velocity for the unarmored threespine stickleback. Also, addition of water in the Santa Clara River population could establish a permanent connection between the population of the unarmored threespine stickleback with the downstream populations of partially armored threespine stickleback, resulting in introgression. Although imported water may increase habitat for the unarmored threespine stickleback, importation of out-of-basin water has already resulted in the introduction of Owens sucker and prickly sculpin into the Santa Clara River drainage. Imported water may also contain a variety of predators, competitors, and parasites that could injure or kill the unarmored threespine stickleback (USFWS 1985; USFWS 2009).

Stressor: Impoundment of water
Exposure:
Response:
Consequence:
Narrative: Impoundments may be beneficial or harmful to the unarmored threespine stickleback. Small impoundments with well-circulated water and abundant aquatic vegetation along the edges support the highest density of the unarmored threespine stickleback; however, large

impoundments without aquatic vegetation are unsuitable for the unarmored threespine stickleback (USFWS 2009).

Stressor: Competition
Exposure: Urbanization, channelization, and a number of other sources.
Response: Remove individuals or restrict habitats.
Consequence: Extirpation of population, or morphological changes.
Narrative: Competitors may cause extirpation or morphological change of the unarmored threespine stickleback populations. Introductions of competitors have come from a number of sources. Channelization may have provided a route for invasion by fathead minnows (Pimephales promelas) and prickly sculpin (Cottus asper), which were introduced into the Santa Clara River drainage. Urbanization also increases the probability that competitors will be introduced. For example, following urbanization, mosquito abatement typically occurs by stocking water bodies with mosquitofish. Mosquitofish are considered opportunistic feeders, foraging on more than 50 types of plant and animal life, including micro- and macro-invertebrate species upon which the unarmored threespine stickleback prey (USFWS 2009).

Stressor: Stochastic extinction
Exposure: Isolated or small populations.
Response: Varied
Consequence: Potential extirpation of population, or loss of "unarmored" individuals.
Narrative: The unarmored threespine stickleback remains at only five small, disjunct populations. Species consisting of small populations, such as the unarmored threespine stickleback, are recognized as being vulnerable to extinction as a result of stochastic (i.e., random) threats. If an extirpation event occurs in an isolated population, the opportunities for natural recolonization are reduced or nonexistent due to physical isolation from other populations (USFWS 2009).

Recovery

Reclassification Criteria:
The unarmored threespine stickleback will be considered for downlisting to threatened status when the following objectives have been achieved:

Identify the factors responsible for threatening the integrity of the known remaining habitats, and take actions to stabilize habitat conditions.

Address other known threats to extant populations in a manner that ensures the continued existence of these populations.

Maintain at least three self-sustaining populations within the historical range of unarmored threespine stickleback for a period of 5 consecutive years without significant threats to their continued existence.

Delisting Criteria:
The unarmored threespine stickleback can be considered for delisting when downlisting objectives have been achieved and:

When at least five self-sustaining populations within the historical range of unarmored threespine stickleback for a period of 5 consecutive years without significant threats to their continued existence.

Recovery Actions:

- Restore and maintain unarmored threespine stickleback essential habitat at optimum conditions (USFWS 1985).
- Restore and maintain unarmored threespine stickleback populations at optimum conditions (USFWS 1985).
- Determine unarmored threespine stickleback life history and obtain needed ecological and genetic information (USFWS 1985).
- Inform the public of unarmored threespine stickleback status and recovery efforts (USFWS 1985).
- Use laws and regulations to protect fish and habitat (USFWS 1985).
- A nuclear DNA study of each population should be conducted to further support the taxonomic status of each population and determine from which populations unarmored threespine stickleback should be collected for re-establishing extirpated locations (e.g., San Francisquito and Bouquet Canyons) (USFWS 2009).
- Evaluate and implement translocation of the unarmored threespine stickleback where appropriate (e.g., San Francisquito and Bouquet Canyons) (USFWS 2009).
- Establish a program for routine monitoring of the unarmored threespine stickleback populations. The goals of the program would be to establish current status, detect declines, identify threats, and determine appropriate remediation (USFWS 2009).
- Develop and implement management plans for extant unarmored threespine stickleback populations which address specific threats at each population location (USFWS 2009).
- Acquire, or otherwise secure for the conservation of the unarmored threespine stickleback, property in areas that have suitable habitat for the unarmored threespine stickleback (e.g., Soledad Canyon, Santa Clara River, or Shay Creek vicinity) (USFWS 2009).
- Consider describing the taxonomy of the Shay and San Antonio Creek populations of the unarmored threespine stickleback in a peer-reviewed journal. Currently, unpublished literature (Haglund and Buth 1988, Buth and Haglund 1994) indicates that these populations are different subspecies from Gasterosteus aculeatus williamsoni. Until the taxonomy and distribution of the subspecies is clarified and adopted, jeopardy determinations will be based on the current distribution of G.a. williamsoni, which may result in underestimating the impacts of projects on less widely distributed subspecies. By recognizing the different subspecies, the U.S. Fish and Wildlife Service could conduct more effective conservation for the unarmored threespine stickleback (USFWS 2009).
- Revise the 1985 recovery plan for the unarmored threespine stickleback (USFWS 2009).
-

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: In 2018, the Service formed the unarmored threespine stickleback Recovery Team. The following is a summary of the Team’s recommendations to prevent extinction and promote recovery of the subspecies: 1. Reintroduce unarmored threespine sticklebacks to increase the number of occupied locations. If wild unarmored threespine sticklebacks are in trouble, conduct rescue. Translocate unarmored threespine sticklebacks from sites that contain high enough abundance to reintroduce into extirpated sites, new sites, or bolster existing sites that need assistance. Conduct rescues and reintroductions with as many fish as possible with consideration of not depleting the source (unless it is thought to be eliminated if not rescued) and the carrying capacity of the receiving site. 2. Undertake captive propagation of the Soledad Canyon genetic strain for bolstering existing sites, reintroduction into recently extirpated sites, and additional suitable sites. The Soledad Canyon genetic strain is the ancestral strain and can be used to reintroduce fish to all sites in the Santa Clara River watershed. Captive bred fish from this strain should be reintroduced into Soledad Canyon sites, Fish Canyon Creek, San Francisquito Canyon Creek, and mainstem Santa Clara River to bolster existing sites and/or repatriate recently extirpated sites. Monitor effectiveness. 3. Investigate unoccupied sites inside and outside of the historic range for reintroduction of unarmored threespine sticklebacks. Evaluate unoccupied sites for reintroduction of unarmored threespine sticklebacks to increase redundancy and reduce the risk of extinction from catastrophic events. Once sites are determined to be suitable, wild translocated or captive reared fish can be introduced. 4. Undertake restoration of unarmored threespine sticklebacks in Bouquet Canyon. Determine the best way to eradicate hybrids. Reintroduce wild translocated or captive reared fish. Monitor effectiveness. 5. Further understanding of unarmored threespine stickleback genetics Verify the genetic source of Pine Valley. Provide a definitive genetic test of whether the different unarmored threespine stickleback populations have evolved in parallel, or whether they share a more recent common ancestor with each other versus other populations. (USFWS, 2021)

Additional Threshold Information:

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SPECIES ACCOUNT: *Gila (=Siphateles) bicolor ssp. Mohavensis* (Mohave tui chub)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; October 13, 1970 (35 FR 16047).

Physical Description

The Mohave tui chub (Siphateles bicolor mohavensis = Gila bicolor mohavensis) is a stocky, large-scaled fish with a small, terminal mouth. This subspecies has a dark-olive to bright-brown back with a silver to bluish-white belly. The fins are olive to rich brown, with the lower fins paling outward. The average size of an adult is 10 to 15 centimeters (cm) (4 to 6 inches [in.]) in length, with the upper range reaching 23 cm (9 in.). The body is thick (chunky), with a large head and short, rounded fins. The snout is short, the mouth oblique, the interorbital space broad and rather flat, and the dorsal outline of the head is slightly concave. A distinct hump sometimes develops behind the head in older fish. The lateral line is complete and decurved, and each scale has a definitive dark border with a lighter center. The Mohave tui chub does not exhibit obvious sexual dimorphism (USFWS 1984; USFWS 2009).

Taxonomy

The Mohave tui chub is a member of the minnow family (Cyprinidae). The Mohave tui chub has a distinct lineage and is a separate subspecies from its closest relative, the Lahontan Lake and Lahontan creek tui chubs (Siphateles bicolor pectinifer and Siphateles bicolor obesa, respectively). Mohave tui chub is least similar genetically to arroyo chub (Gila orcuttii) (USFWS 1984). The Mohave tui chub has undergone a change in nomenclature; the genus has changed from Gila to Siphateles. Using mitochondrial and ribosomal RNA sequences, the genus Gila was recognized as a monophyletic genus (of primarily Colorado River fishes), and restored Siphateles from a subgenus to a full genus. On review of and in agreement with available systematic literature and on consultation with species experts, the U.S. Fish and Wildlife Service intends to propose amending part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, to reflect the taxonomic change from Gila bicolor mohavensis to Siphateles bicolor mohavensis. This change does not alter the definition or distribution of the listed entity Mohave chub or Mohave tui chub (USFWS 2009). Several key characteristics of the Mohave tui chub separate it from other tui chubs. These include: shield-shaped scales; lack of lateral or basal scale radii; low lateral-line scale counts (44 to 55); low number of scale radii (6 to 12); high number of anal fin rays (7 to 9); the pharyngeal tooth formula is typically 0,5-5, 0, but as many as 30 percent may be 0, 5-4,0; and numerous gill rakers (18 to 29, usually 21 to 27) (USFWS 1984).

Historical Range

Historically, the Mohave tui chub is believed to have occurred throughout the Mojave River drainage. The Mojave River drainage in the Mojave Desert originally consisted of the Mojave, Little Mojave, and Manix lakes; during the Pleistocene age, these lakes were connected through channels, and Mohave tui chubs were probably found throughout the drainage. As the climate became drier and the lakes receded, the Mohave tui chub was restricted to the Mojave River.

During the 1930s, arroyo chubs (Gila orcuttii) were introduced into the Mojave River and likely hybridized with the Mohave tui chub, thus eliminating the genetically pure Mohave tui chub in the Mojave River. A small population of genetically pure Mohave tui chub persisted in isolated ponds near the terminus of the Mojave River at Soda Springs (USFWS 1984).

Current Range

There are currently three populations of genetically pure Mohave tui chubs, with two sites to be added for reintroduction: Soda Springs at Mojave National Preserve, Lark Seep at China Lake Naval Air Weapons Station, and Camp Cady Wildlife Area. The Lewis Center in Apple Valley and Morning Star Mine at Mojave National Preserve are sites for reintroduction. The Camp Cady Wildlife Area is managed by California Department of Fish and Wildlife; Soda Springs Mojave National Preserve and Morning Star Mine are managed by the National Park Service; and the Lark Seep complex is located on a naval base managed by the Department of Defense (USFWS 2009).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Mohave tui chub are specialist herbivores and invertivores that eat plankton, insect larvae, small fish, and organic detritus. The species food resources are widely distributed. Mohave tui chub exhibit increased activity as water temperature increases. The species has been known to compete with bass (Micropterus spp.), catfish (Ictalurus spp.), trout (Oncorhynchus spp.), bullfrog (Rana catesbeiana), crayfish (Procambarus clarki), and arroyo chub (Gila orcutti). For feeding, the species requires aquatic plants (e.g., aquatic ditchgrass [Ruppia maritima], cattails [Typha spp.], and rushes [Juncus spp.]), which provide habitat for aquatic invertebrates. They also require ponds and pools that support aquatic vegetation. The diet of a Mohave tui chub shifts to greater consumption of insect larvae and smaller fish as its size and age increases (USFWS 2009).

Reproduction Narrative

Adult: Mohave tui chub reproduce through broadcast spawning over aquatic plants. Mohave tui chubs spawn after 1 year of age; they usually have one reproductive event per year, with up to two per year possible. The species has high fecundity, with each female producing from 4,000 to 50,000 eggs per breeding season. The species leave their young to fend for themselves, and have a life expectancy that is likely several years. During spawning, eggs are attached to aquatic plants; aquatic ditchgrass (Ruppia maritima) appears to be the preferred vegetation for egg attachment. The species spawns in March or April, when water warms to 18 degrees °C (64.4 °F); they may spawn again in fall. Mohave tui chub require ponds that can support aquatic ditchgrass. The species lays eggs that are approximately 1 mm (0.04 in.) in diameter and hatch after approximately 6 to 8 days, when water temperatures are between 17.7 and 20°C (64 and 68°F) (USFWS 1984; USFWS 2009).

Geographic or Habitat Restraints or Barriers

Adult: Mohave tui chub require a minimum water depth of 4 ft.; they are not able to persist in conditions with high-velocity flow and warmer shallow channels (USFWS 2009).

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Narrow/specialist

Tolerance Ranges/Thresholds

Adult: High

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: Aquatic ditchgrass (Ruppia maritima) is used as a thermal refuge in summer months (USFWS 1984).

Habitat Narrative

Adult: Mohave tui chub occupy riverine habitat; deep lacustrine pools or shallow outflow streams of mineralized, and alkaline waters. Formerly, the species occurred in mainstem Mohave River. Dominant plants in its habitat include ditchgrass (Ruppia maritima), bulrush (Typha spp.), cattail, rush, and saltgrass. The configuration of a lacustrine pond or pool for the species should include a minimum water depth of 4 ft., with some freshwater flow for a mineralized and alkaline environment. Mohave tui chub require a minimum depth of 4 ft. for ponds; they are not able to persist in conditions with high-velocity flow and warmer shallow channels. Two of the three pools at Soda Springs are artificially excavated ponds; the other is a spring 2 meters (m) by 3 m [6.5 by 10 ft.]) in diameter (NatureServe 2015; USFWS 1984; USFWS 2009).Spatially, the populations are clumped, and environmentally they are narrow specialists. The species has a relatively high tolerance in habitats, and is capable of surviving low-oxygen (1 mg oxygen per liter), high-alkaline (pH 9 to 10) environments. Mohave tui chub require aquatic ditchgrass to be used as a thermal refuge in summer months; and water quality parameters that include a temperature range from 2.8 to 36.1°C (37° to 97°F), dissolved oxygen at greater than 2 ppm, a salinity of 40 to 323 milliosmoles per liter, and a pH of up to 9, with 10 being tolerable for a short period of time (USFWS 1984; USFWS 2009).

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Currently, the populations of Mohave tui chub are restricted to ponds and man-made channels where they do not have any connection to other populations (USFWS 2009).

Immigration/Emigration

Adult: No

Dispersal/Migration Narrative

Adult: Mohave tui chub are nonmigratory, with moderate mobility throughout their habitat. Currently, the populations of Mohave tui chub are restricted to ponds and man-made channels where they do not have any connection to other populations. The species does not immigrate nor emigrate, and requires low-flowing channels and ponds for movement. Mohave tui chubs are adapted to lacustrine conditions, and are not able to persist in conditions with high-velocity flow and warmer shallow channels (USFWS 2009).

Additional Life History Information

Adult: Mohave tui chubs are adapted to lacustrine conditions, and are not able to persist in conditions with high-velocity flow and warmer shallow channels (USFWS 2009).

Population Information and Trends

Population Trends:

Decline in most populations (NatureServe 2015).

Species Trends:

In the short-term, the overall population is declining by 10 to 30 percent (NatureServe 2015).

Number of Populations:

There are three populations of Mohave tui chub, at Soda Springs at Mojave National Preserve, Lark Seep at China Lake Naval Air Weapons Station, and Camp Cady Wildlife Area (USFWS 2009).

Population Size:

There are approximately 10,000 individuals: 1,573 in Soda Springs (1,318 fish in Lake Tuendae [a reduction of about 50 percent from the October 2005 population estimate] and 255 fish in MC Spring); 3,607 fish in Camp Cady; and 6,000 fish in Lark Seep (USFWS 2009).

Minimum Viable Population Size:

There are approximately 500 individuals; to downlist the Mohave tui chub from endangered to threatened, the Recovery Plan states that three more populations need to be established, with a minimum population of 500 fish at each location (USFWS 2009).

Adaptability:

Moderate

Additional Population-level Information:

The Mohave tui chub has almost been eliminated as a distinct subspecies as a result of extensive hybridization with introduced Arroyo chub (Gila orcutti) (NatureServe 2015).

Population Narrative:

The Mohave tui chub has seen a short-term decline by 10 to 30 percent. The species currently consists of three populations: Soda Springs at Mojave National Preserve, Lark Seep at China Lake Naval Air Weapons Station, and Camp Cady Wildlife Area. The population is estimated to be approximately 10,000 individuals. Based on the species' downlisting criteria, the minimum viable population size for the species is approximately 500 individuals. The Mohave tui chub was almost eliminated as a distinct subspecies as a result of extensive hybridization with introduced Arroyo chub (Gila orcutti). When listed as endangered in 1970, there were four populations of the Mohave tui chub (Paradise Spa, Piute Creek, Two Hole Spring, and Soda Springs). Since listing, three of these populations have failed. From the time of listing to now, 10 populations of Mohave tui chubs have been introduced at other locations, some more than once. Only two have been successful: Lark Seep and Camp Cady. Despite numerous efforts to establish additional populations, the number of populations of Mohave tui chubs has declined from four to three (Soda Springs, Camp Cady, and Lark Seep) since 1970 (USFWS 2009; NatureServe 2015).

Threats and Stressors

Stressor: Loss and degradation of aquatic habitat at historical occurrences
Exposure: Dams and diversions throughout habitat.
Response: Loss and/or reduction of suitable habitat.
Consequence: Population decline/extirpation.
Narrative: Historically, the Mohave tui chub was found in deep pools, slough-like habitats, and slow-moving areas of the Mojave River. The Cedar Springs Dam and Mojave River Dam have restricted and diverted water flow from reaching most of the desert portion of the Mojave River that historically provided habitat for the Mohave tui chub. With damming and diverting of its water from the headwaters to near Afton Canyon, most of the Mojave River flow is now subsurface, except during period of very high flows. Overdrafting of the aquifer of the Mojave River has been ongoing for several decades. The river and the aquifer system are hydraulically connected in many areas, and when one changes, the other is usually affected. Because of this overdrafting, water levels in wells declined and there has been a major loss of riparian habitat. In the Mojave River basin, activities to dam, divert, and pump surface and groundwater continue to increase to supply the demands of an ever-growing human population from the San Bernardino Mountains to the Victor Valley and Barstow. As a result, only a few perennial stretches of the river remain where Mohave tui chub could potentially be reintroduced. Consequently, because of human alteration of water flows in the Mojave River and its aquifer, suitable habitat for the Mohave tui chub is now scarce (USFWS 2009).

Stressor: Loss or degradation of habitat at current population locations
Exposure: Clogged waterways from emergent vegetation.
Response: Loss and/or reduction of suitable habitat.
Consequence: Population decline/extirpation.
Narrative: Currently, there are three populations of Mohave tui chubs. All require regular control of cattails to provide open water for Mohave tui chubs. Without this control, the open waterways become clogged with emergent vegetation, and accumulate detritus. This condition reduces water depth, elevates water temperature, and can result in severe anoxic conditions. Although Mohave tui chubs continue to exist at these locations, their continued survival depends on routine maintenance of their habitat. Three of the four ponds are man-made; therefore, the water quantity and quality must be controlled and managed (USFWS 2009).

Stressor: Habitat conservation needed to recover the species
Exposure: Need of proper management, restoration, and monitoring.
Response: Potential for mismanagement, or lack of funding for proper management.
Consequence: Population decline/extirpation.
Narrative: Beyond establishing additional populations and reducing or removing the current threats to each population, other conservation measures, such as habitat management, ecosystem restoration, monitoring, and adaptive management, are necessary to ensure the long-term sustainability of the Mohave tui chub. None of the populations has sufficient guaranteed funding for systematic monitoring and adaptive management to determine habitat quality, population trends, presence of disease, or other threats that may appear but will not be detected and managed. All three populations are managed by controlling human access to limit threats from direct human contact (e.g., fishing, pollution, and introduction of nonnative species), and by conducting periodic cattail removal. However, all three populations draw their water from artificial sources. If these man-made sources of water are altered in either quantity or quality, this could adversely affect the survival of these populations. Previously, changes in water quality and quantity resulted in the loss of Mohave tui chub subpopulations at East Pond (Camp Cady) and Three Bats Pond (Soda Springs) (USFWS 2009).

Stressor: Disease
Exposure: Parasitic Asian tapeworm.
Response: Enlargement of the abdomen, with severe hemorrhagic enteritis and intestinal blockage.
Consequence: Reduced growth in individuals.
Narrative: The parasitic Asian tapeworm appeared in the Mohave tui chub population at Lake Tuendae at about the same time as mosquitofish. Asian tapeworms cause a marked enlargement of the fish's abdomen, with severe hemorrhagic enteritis and intestinal blockage. Initially, the Asian tapeworm had a deleterious effect on the Mohave tui chub population at Soda Springs (Lake Tuendae). In captivity, Asian tapeworms reduced the growth rate of Mohave tui chubs, but did not reduce survival. The prevalence and intensity of infection of this parasite were both greater with warmer versus colder water temperatures. Water depth in the few areas in the historical habitat of the Mohave tui chub that still have perennial flows is shallower than in the past, resulting in higher water temperatures. Therefore, these conditions would likely further exacerbate the effect of the Asian tapeworm. Larger Mohave tui chubs are associated with higher infection intensities; conversely, smaller Mohave tui chubs are associated with lower infection intensities. Because high intensity infections might kill a small fish, this may explain why only small fish with low-intensity infections may be more likely to survive. The prevalence of the Asian tapeworm in a Mohave tui chub population appears to decline within a few years after the initial infection (USFWS 2009).

Stressor: Predation
Exposure: Predation by introduced aquatic species.
Response: Population decline.
Consequence: Reestablishment not likely to be successful.
Narrative: The Mohave tui chub is the only fish native to the Mojave River. Therefore, it evolved in an environment with little threat from aquatic predators. Predation by introduced aquatic species was one of the threats that contributed to the listing of the Mohave tui chub as endangered. Bullfrogs and nonnative sport fish (e.g., bass, catfish, and bluegills) were introduced to provide recreational fishing opportunities in the Mojave River and its impoundments. Stocking

of these fish species continues by local groups. As a fish that evolved with no predation pressure, the reestablishment of the Mohave tui chub in the Mojave River is not likely to be successful until predation is reduced (USFWS 2009).

Stressor: Regulatory mechanisms
Exposure: Inadequacy of existing regulatory mechanisms.
Response: See narrative.
Consequence: Loss of individuals or population, and habitat degradation or loss.
Narrative: The use of existing regulatory mechanisms to conserve and help recover the Mohave tui chub is ongoing. There are no recently proposed or initiated activities that would incidentally take the Mohave tui chub, with the exception of the recent introduction of mosquitofish by unknown parties at Lake Tuendae. Military installations comply with the federal Endangered Species Act (ESA) and, in the case of China Lake Naval Air Weapons station, implement Section 7(a)(1) of the ESA to use their authorities in the furtherance of the purposes of the ESA by carrying out programs for the conservation of federally endangered and threatened species. Therefore, the California ESA is inadequate to protect the Mohave tui chub from take on military lands in California, and inadequacy of existing regulatory mechanisms is a threat to the Mohave tui chub (USFWS 2009).

Stressor: Hybridization
Exposure: Mohave tui chub hybridizing with Arroyo chub.
Response: Population decline.
Consequence: See narrative.
Narrative: Mohave tui chubs hybridize with introduced arroyo chubs. Native to the Los Angeles Basin, the arroyo chub was geographically isolated from the Mohave tui chub by the San Bernardino and San Gabriel mountains. Currently, Mohave tui chubs at Soda Springs remain genetically and geographically isolated from the Mojave River. All of the known stock of Mohave tui chubs in existence today emanate from Soda Springs. Genetically pure offspring from these chubs are currently at locations isolated from the Mojave River, Lake Tuendae, Camp Cady, and Lark Seep. Most of these are less than 0.8 hectare (2 acres) in size, and are similar to zoo or captive environments. Similarly, fish sampled recently from the Mojave River are pure arroyo chubs with no indication of hybridization (USFWS 2009). The verification of hybrids and the viability of their offspring has not been tested and confirmed through genetic analysis or scientific experimentation. Mojave National Preserve initiated a study in late 2007 in a controlled environment to determine whether Mohave tui chubs will breed with arroyo chubs and whether the F1 generation (the offspring produced by crossing two parental lines) can breed (USFWS 2009).

Stressor: Genetic drift
Exposure: Small isolated populations prone to dramatic genetic shifts.
Response: Population decline and extirpation.
Consequence: See narrative.
Narrative: Genetic drift is the occurrence of random changes in the gene frequencies of small isolated populations. The Mohave tui chubs at MC Spring and Camp Cady have recently shown a loss of genetic diversity. The Mohave tui chub has experienced decades of confinement at two small isolated sites at Soda Springs, initially with a small population size. Although genetically diverse, the Mohave tui chub population at Soda Springs (Lake Tuendae) is different genetically from the population at Lark Seep (USFWS 2009).

Stressor: Competition
Exposure: Competition resulting from man-caused changes in species composition and habitat.
Response: Population decline.
Consequence: See narrative.
Narrative: Competition resulting from man-caused changes in species composition and habitat in the Mojave River also threaten the Mohave tui chub. The introduced arroyo chub has replaced the Mohave tui chub in the Mojave River. Humans have severely altered the water flows in the Mojave River. Because the introduced arroyo chub is better adapted than the Mohave tui chub to these current fluctuating water conditions and has a longer evolutionary history in fluctuating stream habitats, this adaptation has contributed to the replacement of the Mohave tui chub with the arroyo chub in the Mojave River (USFWS 2009).

Stressor: Climate Change
Exposure: Species unable to adapt to quickly changing climate.
Response: Population decline and extirpation.
Consequence: See narrative.
Narrative: Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying. It is unknown at this time if climate change in California will result in a warmer trend with localized drying, higher precipitation events, or other effects. Nonetheless, climate change is expected to affect hydrology in the Mojave Desert through changes in the amount and timing of precipitation supplied to the Mojave River and its aquifer. The aquifer that supplies water directly to Soda Springs (MC Spring) and Afton Canyon is the source of pumped water at Soda Springs (Lake Tuendae) and Camp Cady. During extreme drought, the reductions in water levels in this aquifer, which are recharged by precipitation events, would likely decline. Water level declines in the few remaining Mohave tui chub habitats would have severe consequences to the future of the subspecies, and potentially result in the reduction or loss of these habitats. The demand for water in the Mojave Desert will continue to increase. Although we recognize that climate change is an important issue with potential effects to listed species and their habitats, we lack adequate information to make accurate predictions regarding its effects to particular regions or species at this time (USFWS 2009).

Stressor: Stochastic Extinction
Exposure: If an extirpation event occurs in an isolated population, the opportunities for natural recolonization are reduced or impossible, due to physical isolation from other populations.
Response: Population extirpation.
Consequence: See narrative.
Narrative: The Mohave tui chub occurs at three small, disjunct populations. The conservation biology literature commonly notes the vulnerability of taxa only occurring at one or a few locations. Such populations may be highly susceptible to extirpation due to chance events or additional environmental disturbance, such as adverse effects from changes in hydrology or temperatures due to climate change, introduction of nonnative species, or failure to maintain habitat requirements at man-made locations. If an extirpation event occurs in an isolated population, the opportunities for natural recolonization are reduced or impossible, due to physical isolation from other populations (USFWS 2009).

Recovery

Reclassification Criteria:
To downlist the Mohave tui chub from endangered to threatened, the three existing populations should be preserved and an additional three populations need to be established (for a total of six). Each established location should have a minimum population of 500 fish. These populations should be located adjacent to the Mojave River to be in or along the historical habitat of the Mohave tui chub. All six populations need to remain free of any threats to their integrity for 5 consecutive years, and the populations should have been exposed to and survived a flood before reclassifying to threatened (USFWS 1984; USFWS 2009).

Delisting Criteria:
To delist the Mohave tui chub, the subspecies needs to be successfully reestablished in a majority of its historical habitat in the Mojave River. This will require extensive rehabilitation efforts and removal of the arroyo chubs. Reestablishment means that the populations of Mohave tui chub are viable. Specific tasks to achieve delisting were not presented in the Recovery Plan, but are to be developed pending evaluation of results of experimental reintroductions (USFWS 1984; USFWS 2009).

Recovery Actions:
- Preserve and enhance existing Mohave tui chub populations and their habitats. Activities to accomplish this criterion are: a) manage and/or improve habitat through control of aquatic vegetation; b) deepen water bodies, as required; c) ensure water quality and quantity; and d) manage chub populations through conducting annual censuses and mixing populations, if necessary, to prevent genetic inbreeding (USFWS 1984; USFWS 2009).
- Establish and protect Mohave tui chub populations in suitable new or restored habitats. For downlisting, the actions include determining the suitability of a new site for introduction of a Mohave tui chub population; improving or constructing habitat, as needed; developing and implementing a land protection plan and land management plan; and controlling nonnative species. For delisting, the actions include reestablishing Mohave tui chub populations in the mainstream Mojave River by evaluating flood potential and effects on stream morphology; enhancing habitats; controlling nonnative species; developing and implementing a management plan; monitoring transplants; and mixing populations, as necessary (USFWS 1984; USFWS 2009).
- Determine Mohave tui chub life history and ecology to better manage and recover the species. This would be accomplished through identifying the extent and magnitude of bird predation, determining spawning requirements and early life history, determining physiological tolerances of Mohave tui chubs and arroyo chubs to water quality parameters, and identifying genetic issues such as founder effect and possible hybridization with arroyo chubs (USFWS 1984; USFWS 2009).
- Use existing regulatory methods to protect the Mohave tui chub and its habitats through enforcement of applicable laws, and evaluation of effectiveness of these laws (USFWS 1984; USFWS 2009).
- Provide public outreach on the status of the Mohave tui chub and recovery efforts through media releases, preparation and distribution of brochures, publication of articles in popular and scientific journals, and creation and maintenance of interpretive centers (USFWS 1984; USFWS 2009).

- Continue to manage existing populations of the Mohave tui chub and their habitats. Identify possible new locations for new populations; assess their likelihood for success; and establish, manage, and monitor all populations (USFWS 2009).
- An outreach or public education plan should be developed, implemented, and coordinated with law enforcement to promote the successful establishment of the Mohave tui chub at additional locations, including the Mojave River; and to address ongoing threats, including introduction of nonnative fish species (USFWS 2009).
- Include the Mojave River watershed in the areas for consideration for establishment of Mohave tui chub populations. This should include tributaries of the Mojave River, including Deep Creek, where the subspecies historically occurred (USFWS 2009).
- Develop management plans for each of the existing and future introduced populations of Mohave tui chubs. Management plans would include procedures to deal with genetic drift; diseases; and standardized monitoring for population and habitat parameters such as population size, population distribution, reproduction, recruitment, unusual mortality, signs of disease or anomalies, introduction of other nonnative species, habitat configuration, and water quality (USFWS 2009).
- Conduct research to determine whether the Mohave tui chub hybridizes with the arroyo chub; if so, determine whether the F1 and F2 generations are fertile or sterile (USFWS 2009).
- Conduct research to determine under what habitat conditions the Mohave tui chub can persist in the Mojave River given the threats of hybridization, predation, and introduction of disease and parasites from nonnative aquatic species (USFWS 2009).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: Since listing, efforts have been made to conserve habitat in the five populations currently believed to be extant. Habitat loss and alteration, nonnative predation, genetic drift, extirpation from stochastic events, and climate change continue to be the major threats. Maintaining, restoring, and conserving habitat has helped conserve the species. Recovery will require stabilizing and managing the five current populations and establishing new populations as described in the Recovery Plan. The biggest hurdle in recovery is establishing new self-sustaining populations that can withstand stochastic events. To be self-sustaining, each population will need to be managed to minimize impacts from inbreeding, predation, and maintain genetic diversity within the population. We have identified these recommendations to aid recovery of the Mohave tui chub: 1. Stabilize existing habitat and potentially establish a new resilient population. 2. Conduct thorough genetic testing to determine genetic diversity at each population. 3. Conduct comprehensive surveys of all populations to obtain current population sizes, density, and trends. 4. Continue to manage existing populations of the Mohave tui chub and their habitats. Identify possible new locations for new populations; assess their likelihood for success; and establish, manage, and monitor all populations. 5. An outreach or public education plan should be developed and implemented to promote the successful establishment of the Mohave tui chub at additional locations including the Mojave River and address ongoing threats including introduction of nonnative fish species. 6. Include the Mojave River watershed in the areas for consideration for establishment of Mohave tui chub populations. This should include tributaries of the Mojave River, including Deep Creek, where the subspecies historically occurred. 7. Develop management plans for each of the existing and future introduced populations of Mohave tui chubs. Management plans would include procedures to address genetic drift; diseases; and standardized monitoring for population and habitat parameters such as population size, population distribution, reproduction, recruitment, unusual mortality, new nonnative species, habitat configuration, and water quality and availability. 8. Conduct research to determine whether the Mohave tui chub hybridizes with other fishes that occur at potential reestablishment sites (i.e. arroyo chub and hitch); if so, determine if the F1 and F2 generations are fertile or sterile. (USFWS, 2020)

Additional Threshold Information:

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USFWS. 2020. 5-YEAR REVIEW Mohave Tui Chub (Gila bicolor mohavensis). 4 pp.

SPECIES ACCOUNT: *Gila bicolor (=Siphateles) ssp. Snyderi* (Owens tui chub)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; August 5, 1985 (50 FR 31592).

Physical Description

The Owens tui chub (Siphateles bicolor snyderi) is a member of the minnow family (Cyprinidae). Individuals range from 15 millimeters (mm) (0.6 inches [in.]) to 180 mm (7 in.) in length. This fish is dusky olive in color from above, with a gold-colored head. The sides of the body are blue and gold. The fins are olive brown to reddish-brown. The Owens tui chub is distinguished from other tui chubs by the presence of lateral radii on the scales, with a rounded or shield-shaped scale base (USFWS 2009).

Taxonomy

The Owens tui chub was described in 1973 as a subspecies of Gila bicolor endemic to the Owens Basin (USFWS 1998). Using mitochondrial and ribosomal RNA sequences, Gila was recognized as a monophyletic genus primarily of Colorado River fishes, and the genus Siphateles was restored from a subgenus to a full genus. The Owens tui chub was previously classified in the subgenus Siphateles. This usage was subsequently widely adopted by the scientific community. Based on this information, the nomenclature change from Gila bicolor snyderi to Siphateles bicolor snyderi was made in 1998 (USFWS 2009). Some evidence suggest that this subspecies might merit recognition as a distinct species. Recent genetic analysis of several populations revealed two distinct lineages: an Owens lineage and a Toikona lineage (NatureServe 2015). The Owens tui chub is similar morphologically to the Mohave tui chub (Siphateles bicolor mohavensis), which occurs to the south of the Owens tui chub in the Mojave Desert; and the Lahontan tui chub (Siphateles bicolor obesa), which occurs to the north in the Walker River. The similarity of these three subspecies, plus hydrographic evidence, suggests that the drainages where these species currently occur were once connected, although not contemporaneously (USFWS 2009).

Historical Range

Historically, the Owens tui chub occurred in large numbers in suitable habitat throughout the Owens Basin, in Mono and Inyo counties, California. The range included the Owens Lake, Owens River and associated tributaries, springs, drainage ditches, and irrigation canals. Capture efforts by researchers in the late 19th and early- to mid-20th centuries suggest that the Owens tui chub was common in the Owens Valley floor. By 1973, the population size and range of the species had been drastically reduced (USFWS 2009).

Current Range

Currently, Owens tui chub (i.e., populations that have not hybridized with Lahontan tui chub (Siphateles bicolor pectinifer)) is restricted to five small, isolated sites within its historical range in the Owens Basin: Hot Creek headwaters (only CD Spring), Little Hot Creek Pond, Upper Owens Gorge, Mule Spring, and White Mountain Research Center, operated by the University of California (Figure 1). A sixth refuge population exists in Sotcher Lake near Devil’s Postpile

National Monument in Madera County, California; which is outside the historical range of the species (CDFW 2021). (USFWS 2022).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/5/1985.

Legal Description

On August 5, 1985, the U.S. Fish and Wildlife Service, designated critical habitat for Gila bicolor ssp. Snyderi (Owens Tui chub) under the authority of the Endangered Species Act of 1973 (50 FR 31592 - 31597). Critical habitat was designated for two units in Mono County, California.

Critical Habitat Designation

Two critical habitat units are described in Mono County, California (43 FR 39042 - 39044).

1. Hot Creek, adjacent springs and their outflows in the vicinity of Hot Creek Hatchery, and 50 feet of riparian habitat on all sides of the creek and springs in T3S, R28E, SW 1/4 Section 35.

2. Owens River, and 50 feet on both sides of the river, from Long Valley Dam downstream for 8 stream miles in T4S, R30E, Sections 19, 20, 21, 22, 23, 24, 25, and 36.

Primary Constituent Elements/Physical or Biological Features

Known constituent elements include high quality, cool water with adequate cover in the form of rocks, undercut banks, or aquatic vegetation and a sufficient insect food base (43 FR 39042 - 39044).

Life History

Feeding Narrative

Adult: The Owens tui chub is an opportunistic omnivore, consuming aquatic insects, vegetation, and detritus. Owen tui chub face competition in their environments from nonnative insectivorous fish at Hot Creek Headwaters, and Little Hot Creek Pond. Owens tui chubs feed mainly by gleaning and grazing among submerged vegetation. Its diet varies seasonally; the dominant items in its diet are chironomid larvae and algae in spring, chironomid larvae in summer, hydroptilid caddisflies in fall, and chironomid larvae in winter. Growth during the first summer is rapid. Owens tui chub need dense aquatic vegetation for cover, and for habitat for insect food items (USFWS 2009).

Reproduction Narrative

Adult: For Owens tui chubs in springs with constant water temperature, sexual maturity is reached at 2 years of age for females and 1 year of age for males. At other sites with varied temperatures, both male and female Owens tui chubs likely become sexually mature at age 2. Spawning occurs from late winter to early summer at spring habitats, with spawning likely triggered by day length. In riverine and lacustrine or lake-like habitats where water temperatures fluctuate seasonally, the Owens tui chub spawns in spring and early summer, with spawning triggered by warming water temperatures. Spawning usually occurs over gravel substrate or aquatic vegetation, with the eggs adhering to these features. There are multiple spawning bouts during the breeding season, and each female produces large numbers of eggs at each bout. Similar species of tui chubs produce 4,000 to 5,000 eggs per season. Hatching time is likely influenced by water temperature, with eggs hatching earlier in warmer water. Fry congregate in areas with cover. Growth during the first summer is rapid, with yearling fish ranging in size from 22 to 42 mm (0.9 to 1.8 in.) (USFWS 2009).Life expectancy is likely several years. At Hot Creek Headwaters, the age of the oldest fish captured was estimated to be at least 7 years. However, age determination for fish that occupy spring habitats with constant water temperatures is difficult, because growth is relatively constant year-round, and annual marks on otoliths, scales, or bones used to determine age are either absent or unreliable (USFWS 2009).

Geographic or Habitat Restraints or Barriers

Adult: Water infrastructure: dams and weirs. Habitat destruction has destroyed much of the Owen tui chub's habitat.

Spatial Arrangements of the Population

Adult: Clumped according to resources.

Environmental Specificity

Adult: Moderate

Tolerance Ranges/Thresholds

Adult: Moderate

Site Fidelity

Adult: Moderate

Dependency on Other Individuals or Species for Habitat

Adult: No

Habitat Narrative

Adult: The Owens tui chub prefers slow-moving water, with the presence of submerged vegetation and cover (e.g., rocks and undercut banks). Habitat can be found in the Owens River, associated tributaries, springs, sloughs, drainage ditches, and irrigation canals, with dense aquatic vegetation for cover and habitat for insect food items. Much of the aquatic habitat in the Owens Valley has been eliminated or modified since the early 1900s. Water has been dammed, diverted, and transported to Los Angeles for human consumption, or is used locally for agriculture and human consumption. Of the remaining perennial aquatic habitat in the Owens Valley, much of it contains the abiotic features (e.g., water velocity, water quality and cover) needed by the Owens tui chub but not the biotic features (e.g., absence of nonnative aquatic species that prey on or hybridize with Owens tui chubs).Aquatic vegetation is especially important because it provides plant food and habitat for aquatic invertebrates, the main food item of the Owens tui chub. In addition, vegetation is important for predator avoidance, reproduction, and reduced water velocity. Water temperature is usually fairly constant at spring sites (e.g., 15 °C [59 °F]) at Hot Creek Headwaters, but can fluctuate from 2 to 25 °C (36 to 78 °F) in a river (e.g., Owens Gorge). The pH ranges from 6.6 to 8.9, dissolved oxygen varies from 5 to 9.3 (mg/L), and alkalinity varies from 68.0 to 88.4 ppm (NatureServe 2015; USFWS 2009)

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Moderate

Immigration/Emigration

Adult: No

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: Owens tui chub are mobile and nonmigratory. All six locations where the Owens tui chub occurs are isolated from one another. Owen tui chub need proper habitat for dispersal and migration, which includes slow-moving water with the presence of submerged vegetation and cover. One reason the Owens tui chub was extirpated throughout most of its range was introgression (i.e., hybridization) with the introduced Lahontan tui chub (Siphateles bicolor pectinifer). Recent genetic analyses of various populations of presumed pure (i.e., nonintrogressed) Owens tui chubs revealed that some populations were introgressed. These include June Lake, Mammoth Creek, Hot Creek below the fish hatchery, Twin Lakes-Mammoth, Owens River Upper Gorge Tailbay (the area downstream of a dam where water is released into the river after passing through the turbines of a generating station), A1 Drain, C2 Ditch, and McNally Canal.

Additional Life History Information

Adult: One reason the Owens tui chub was extirpated throughout most of its range was introgression (i.e., hybridization) with the introduced Lahontan tui chub (Siphateles bicolor pectinifer).

Population Information and Trends

Population Trends:

Short-term trend: stable; long-term trend: decline of 90 percent (NatureServe 2015).

Species Trends:

Declining

Number of Populations:

Six: Little Hot Creek Pond, Hot Creek Headwaters, Sotcher Lake, Upper Owens Gorge, White Mountain Research Station, Mule Springs (USFWS 2009).

Population Size:

all populations are approximately 100 to 1,000 individuals (USFWS, 2022)

Adaptability:

Moderate

Additional Population-level Information:

Recent genetic analyses of this subspecies and various populations suggest that the Owens tui chub could be considered a separate species (USFWS 2009).

Population Narrative:

When listed in 1985, only two populations of Owens tui chub were believed to exist: one is the Hot Creek Headwaters population, which is located at the headwaters of Hot Creek above the Hot Creek Fish Hatchery; the second population is in the Upper Owens Gorge, located below Long Valley Dam and above the town of Bishop. A third population at Cabin Bar Ranch (owned by the Anheuser Busch Company) was discovered in 1987. Individuals from the Hot Creek Headwaters, Upper Owens Gorge, and Cabin Bar Ranch populations were translocated to establish additional populations of Owens tui chubs. Currently, the Owens tui chub is limited to six isolated sites, and they are isolated from each other. These populations exist in Little Hot Creek Pond, Hot Creek Headwaters, Sotcher Lake, Upper Owens Gorge, White Mountain Research Station, and Mule Springs. Information on Owens tui chub abundance or changes in population size is limited or unknown for these populations, and when counts have been made, the methodologies used to estimate population size have varied. Wide-ranging estimates put the population size between 10,000 and 100,000 individuals. Although it is known that populations currently exist, USFWS is unable to determine whether they are increasing, decreasing, or stable. No information is available on population age structure, sex ratio, or mortality (NatureServe 2015; USFWS 2009).Species consisting of small populations, such as the Owens tui chub, are recognized as being vulnerable to extinction from stochastic threats, such as demographic, genetic, and environmental stochasticity and catastrophic events. Recent genetic analyses of this subspecies and various populations suggest that the Owens tui chub could be considered a separate species. In this possible species designation, there are two distinct genetic lineages: the Owens lineage and the Toikona lineage. Researchers have not proposed a formal taxonomic split of these lineages until more information on meristic (counting quantitative features of fish, such as the number of fins or scales) and osteological characters are available. The population that may have expanded its range is the Upper Owens Gorge population. Individuals thought to be Owens tui chubs were observed in the Lower Owens Gorge in 1995 and 2008 in a portion of the Owens Gorge re-watered since 1992. However, no Owens tui chubs were captured in the Lower Owens Gorge in 1998 despite extensive trapping and electrofishing efforts. Genetic analysis of these fish is needed to determine whether they are pure Owens tui chubs or hybrids (USFWS 2009). Currently, Owens tui chub (i.e., populations that have not hybridized with Lahontan tui chub (Siphateles bicolor pectinifer)) is restricted to five small, isolated sites within its historical range in the Owens Basin: Hot Creek headwaters (only CD Spring), Little Hot Creek Pond, Upper Owens Gorge, Mule Spring, and White Mountain Research Center, operated by the University of California (Figure 1). A sixth refuge population exists in Sotcher Lake near Devil's Postpile National Monument in Madera County, California; which is outside the historical range of the species (CDFW 2021). The Hot Creek headwaters population site consists of two currently separate springs, AB Spring and CD Spring; however, only the population in CD Spring is not hybridized with Lahontan tui chub

(Benjamin and Finger 2016). Irregular data collection has resulted in an unclear picture of current population size or trends for any of the populations, but the best estimates available indicate that all populations are approximately 100 to 1,000 individuals (CDFW 2021). In 2009, no information about population age structure, sex ratio, or mortality rates was known to exist and none has been discovered or collected since (USFWS, 2022).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Water diversion and impoundments, growing populations, agriculture use, and lack of maintenance.
Response: Diversion and impoundment of streams and rivers, changes in water quality and quantity, and habitat degradation.
Consequence: Reduction in suitable habitat, and population fragmentation and loss.
Narrative: Habitat destruction and modification is threatening to the Owens tui chub. Currently, most streams and rivers in the Owens Basin have been diverted and some impounded. The Owens tui chub, which used to occur throughout the Owens River and its tributaries in the Owens Basin, is restricted to six isolated populations, five of which are within the historical range of the species. Of these five populations, three (Hot Creek Headwaters, Little Hot Creek Pond, and Upper Owens Gorge) are in small, isolated, man-altered portions of these waterways. The other two populations (Mule Spring and White Mountain Research Station) exist in man-made ponds at upland sites, with water supplied by artificial methods. The occupied habitat at Hot Creek Headwaters, Little Hot Creek Pond, White Mountain Research Station, and Mule Spring is 0.8 hectare (2 acres) or smaller at each site. The habitats for these five populations are threatened by water diversions, failure of infrastructures that deliver water to these habitats, and/or emergent vegetation (USFWS 2009). Most of the water rights in the Owens Basin are owned by the city of Los Angeles. Currently, the demand for water from the Owens Basin is high and growing as Los Angeles continues to grow. The Los Angeles Department of Water and Power operates and maintains dams, diversion structures, groundwater pumps, and canals to capture and convey much of the water from the Owens Basin to Los Angeles. The remaining groundwater (which provides water to isolated springs and springs that are the headwaters of streams in the Owens Basin) and surface water are used extensively for agriculture and municipal purposes in the Owens Basin. These man-made changes to aquatic habitat in the Owens Basin dramatically reduced suitable aquatic habitat for the Owens tui chub (USFWS 2009). In addition to the increasing water demands for the greater Los Angeles area, areas adjacent to the Owens Valley (e.g., Round, Chalfant, and Hammil valleys) are growing, as is the demand for water. This increased demand has resulted in an increased withdrawal of ground and surface water from the Owens Valley Groundwater Basin (USFWS 2009). Of the five populations within the historical range of the Owens tui chub, two (Mule Spring and White Mountain Research Station) require routine management of water quantity and water quality, and three (Mule Spring, Hot Creek Headwaters, and Little Hot Creek) require routine removal of emergent vegetation. One (Upper Owens Gorge) has been severely altered by the construction of a dam, with no mechanism to manage adequate releases of water downstream of the dam; therefore, there is no way to manage water quantity, water quality, and water velocity in the Upper Gorge. Given the dependency of these populations of the Owens tui chub on the routine maintenance of their habitats, the continued existence of these restricted habitats and the associated populations of Owens tui chubs are tenuous (USFWS 2009).

Stressor: Disease
Exposure: Tapeworm, and bacterial and viral infection.
Response: See narrative.
Consequence: Mortality, and reduction in population numbers.
Narrative: Evidence of disease has been observed in some populations of the Owens tui chub. One Owens tui chub from Cabin Bar Ranch was found with 183 Asian tapeworms (Bothriocephalus acheilognathi). Owens tui chubs are also susceptible to either bacterial infections, viral infections, or water pollution. Because disease has been identified in Owens tui chubs, it is considered a threat. However, the magnitude of this threat is unknown (USFWS 2009).

Stressor: Predation
Exposure: Introduction of nonnative fish into Owen tui chub habitat.
Response: Predation by introduction of fish and bullfrogs.
Consequence: Mortality, reduction in population numbers, and reduction from historical range.
Narrative: Predation by introduced nonnative fish, specifically brown trout (Salmo trutta), is a major threat to the Owens tui chub. Nonnative largemouth bass (Micropterus salmoides) and brown trout have eliminated Owens tui chubs from much of their historical range in the Owens River. The presence of nonnative aquatic predators in the Owens Basin has greatly limited the locations in which the Owens tui chub can survive and persist (USFWS 2009). Much of the recreation-based economy of the Owens Basin depends on recreational fishing, primarily for trout and largemouth bass. Because of the miles of riverine habitat and the historical and current practice of angling in the Owens Basin, it is unlikely that curtailing stocking these species would eliminate them from the Basin. Consequently, restoring the Owens tui chub to most of the Owens River or its connected tributaries is unlikely to occur (USFWS 2009). At Mule Spring, bullfrogs (Lithobates catesbeianus) are present and probably prey on Owens tui chubs. Although there is no report in the literature of direct observations of bullfrog preying on Owens tui chubs, bullfrogs prey on many species of fish, including other subspecies of tui chubs (USFWS 2009).

Stressor: Inadequacy of existing regulations
Exposure: Lack of protection for Conservation Areas.
Response: Water levels are not being protected for the Owens tui chub.
Consequence: Reduction in suitable aquatic habitat for the Owens tui chub.
Narrative: There is no information in the literature that suggests this factor is a direct threat to the Owens tui chub, but there is a concern about indirect effects to the Owens tui chub and its habitat from actions that are not regulated. The unregulated actions are those that may result in the overdrafting of the aquifer in the Owens Valley Groundwater Basin area, which underlies the Benton, Hammil, and Chalfant valleys in Mono County and Round and Owens valleys in Inyo County (USFWS 2009). The Recovery Plan identified protecting spring discharge as a recovery task for the spring-fed Conservation Areas. Springs are supplied by groundwater, and the State of California is responsible for regulating groundwater. However, California has not issued groundwater regulations for the Owen Valley Groundwater Basin. The City of Los Angeles and Inyo County had recently agreed to manage groundwater resources to minimize the effects of groundwater pumping on Owens Valley vegetation. Any reduction in flow from springs in the Owens Basin would result in further reductions of habitat quality and quantity for the Owens tui chub at springs and tributaries of the Owens River. Therefore, inadequacy of existing regulatory mechanisms is a threat at this time (USFWS 2009).

Stressor: Hybridization
Exposure: Introduction of Lahontan tui chubs into Owen tui chub environments.
Response: See narrative.
Consequence: Reduction in pure Owens tui chub numbers.
Narrative: Until recently, the Owens tui chub and the closely related Lahontan tui chub were isolated from each other. Lahontan tui chubs were introduced as baitfish into many of the streams in the Owens Basin. Hybridization between the Owens tui chub and Lahontan tui chub has been documented for populations in Mono County at Hot Creek, Mammoth Creek, Twin Lakes-Mammoth, June Lake, and Owens River Upper Gorge Tailbay; and in Inyo County at A1 Drain, C2 Ditch, and McNally Canal. At present, there are six genetically pure Owens tui. If man-made barriers isolating the Owens tui chub populations at these sites are degraded or removed, this degradation/removal could result in the loss of the pure populations of Owens tui chubs. In addition, the opportunities to establish new populations of Owens tui chubs in the Owens Basin is limited by the presence of hybrids in the Owens River and tributaries, the historical habitat for the Owens tui chub. Currently, the only viable locations for establishing the Owens tui chub are isolated springs or the headwaters of streams with downstream barriers to upstream movement of Lahontan tui chubs or hybrids (USFWS 2009).

Stressor: Competition
Exposure: Introduction of nonnative fish into Owen tui chub habitat.
Response: Competition for Owen tui chub because of the introduction of nonnative fish.
Consequence: Reduction in population numbers.
Narrative: The final listing rule identified competition with nonnative fish species as a threat to the Owens tui chub. Nonnative insectivorous fish occur at Hot Creek Headwaters (rainbow trout) and Little Hot Creek Pond (mosquitofish). The same aquatic insects consumed by Owens tui chubs are a major part of the diets for these nonnative species. Although information is not available for rainbow trout, mosquitofish are known to affect some southwestern native fishes through competition and predation (USFWS 2009).

Stressor: Stochasticity
Exposure: Small and few populations of Owens tui chub.
Response: More susceptible to stochastic events.
Consequence: Higher risk of extinction of Owens tui chub.
Narrative: The creation and maintenance of small and often intensively managed populations has prevented extinction of the Owens tui chub. Only six populations of the Owens tui chub exist, and they are isolated from each other. Species consisting of small populations, such as the Owens tui chub, are recognized as being vulnerable to extinction from stochastic (i.e., random) threats, such as demographic, genetic, and environmental stochasticity and catastrophic events. Currently Owens tui chub populations are small, between 100 and 10,000 individuals; therefore, random events that may cause high mortality or decreased reproduction may have a significant effect on the viability of Owens tui chub populations. Furthermore, because the number of populations is small (six) and each is vulnerable to this threat, the risk of extinction is exacerbated. In small populations such as the Owens tui chub, these factors may reduce the amount of genetic diversity retained in populations, and may increase the chance that deleterious recessive genes are expressed. Loss of diversity could limit the species' ability to adapt to environmental changes, and contributes to inbreeding depression (i.e., loss of reproductive fitness and vigor). Deleterious recessive genes could reduce the viability and reproductive success of individuals. Isolation of the six remaining populations, preventing any

natural genetic exchange, will lead to a decrease in genetic diversity (USFWS 2009).

Stressor: Climate change
Exposure: Global shifts in temperature.
Response: See narrative.
Consequence: See narrative.
Narrative: Impacts to the Owens tui chub under predicted future climate change are unclear. However, a trend of warming in the Sierra Nevada and Inyo mountains is expected to increase winter rainfall, decrease snowpack, hasten spring runoff, reduce summer stream flows, and reduce groundwater recharge. Increased summer heat may increase the frequency and intensity of wildfires. Loss of upland and riparian vegetation leads to soil erosion, increased sedimentation, down-cutting of waterways, loss of bank stabilization, and decreased ability of soils to hold moisture and slowly release it into nearby waterways, all of which would negatively affect Owens tui chub habitat. Although it appears reasonable to assume that the species may be affected, we lack sufficient certainty regarding the magnitude and intensity of these impacts; the timing of these effects to the species; the extent of average temperature increases in California/Nevada; or potential changes to the level of threat posed by drought, fire regime, or heavy rainfall events. The most recent literature on climate change includes predictions of hydrological changes, higher temperatures, and expansion of drought areas, which would result in a northward and/or upward elevation shift in range for many species. Although northward and/or higher elevation habitats could be important factors in the future conservation of this species, currently the isolated populations of the Owens tui chub are unable to access these habitats because of other threats, including a lack of connectivity of habitats caused by physical barriers (e.g., dams and diversion structures); habitat destruction and alteration; and predation, competition, and hybridization with introduced species. The U.S. Fish and Wildlife Service (USFWS) has no more knowledge of more detailed climate change information specifically for the range of the Owens tui chub (USFWS 2009).

Recovery

Reclassification Criteria:
Reproducing and self-sustaining populations of the Owens tui chub must exist throughout six Conservation Areas. Two of the Conservation Areas must be in the Long Valley and four in the Owens Valley. The Conservation Areas are Little Hot Creek, Hot Creek, Fish Slough, Round Valley, Warm Springs, Blackrock, and Southern Owens (USFWS 2009).

Threats must be controlled (USFWS 2009).

Each Conservation Area must have an approved management plan and implementing agreement with the landowner and USFWS (USFWS 2009).

Successful establishment of populations includes the presence of juveniles and three additional age classes of Owens tui chubs (USFWS 2009).

Ensure that hybrid tui chubs do not occur in the Conservation Areas (USFWS 2009).

The biomass of the Owens tui chub must exceed the biomass of deleterious, nonnative fish species at each site (USFWS 2009).

Delisting Criteria:
Owens tui chub delisting may occur when reproducing populations are established as part of self-sustaining native fish assemblages in seven Conservation Areas for a period of 5 consecutive years. Two of the Conservation Areas must be in the Long Valley and five in the Owens Valley. The Conservation Areas are Little Hot Creek, Hot Creek, Fish Slough, Round Valley, Warm Springs, Blackrock, and Southern Owens (USFWS 1998).

Threats must be controlled (USFWS 2009).

Each Conservation Area must have an approved management plan and implementing agreement with the landowner and USFWS (USFWS 2009).

Successful establishment of populations includes the presence of juvenile and three additional age classes of Owens tui chubs (USFWS 2009).

Ensure that hybrid tui chubs do not occur in the Conservation Areas (USFWS 2009).

The biomass of the Owens tui chub must exceed the biomass of deleterious nonnative fish species at each site (USFWS 2009).

Recovery Actions:
- Maintain Owens Tui Chub Refuges. Maintain existing refuges to prevent extinction and provide stock for reestablishing recovery populations in Conservation Areas (USFWS 1998).
- Initiate Conservation Area Management. Although there is much to be determined about appropriate management of Conservation Areas, there is sufficient information to recommend preliminary management actions for each Conservation Area. These tasks should be implemented in accordance with requirements necessary to maintain the persistence and resilience of Owens Basin wetland communities (USFWS 1998).
- Research. The results of research tasks will be used to modify management of Conservation Areas and accomplish other recovery tasks (USFWS 1998).
- Delineate Conservation Area Boundaries. Analysis of ecosystem characteristics, rare species richness, conflicting uses, and the potential for each Conservation Area to successfully accomplish recovery tasks (as analyzed by matrix variables) indicates that Conservation Areas are sites where recovery and protection of rare Owens Basin valley floor wetland species are most likely to be successful (USFWS 1998).
- Prepare Conservation Area Management Plans. Appropriate uses and management should be described in management plans prepared for each Conservation Area (USFWS 1998).
- Implement Conservation Area Management Plans. Recovery task should be implemented in Conservation Areas through the cooperation of government agencies and private parties (USFWS 1998).
- Monitoring Programs. Including population and habitat, genetic, and spring discharge monitoring (USFWS 1998).
- Recovery Information and Education. An information and education program is necessary to involve and inform the public, resource agencies, and others about the purposes, goals, and accomplishments of the Owens Basin multi-species recovery program (USFWS 1998).

- Develop management plans and implementation agreements for all existing and new populations. Implement population monitoring and adaptive management (USFWS 2009).
- Establish and secure additional populations of the Toikona lineage of Owens tui chubs. Increasing the number of populations and the size of each population of the Toikona lineage will conserve the genetic distinctiveness of this evolutionary lineage, maintain the genetic variation, and prevent the loss of alleles. Recommended sites include but are not limited to the Cartago Springs Wildlife Management Area and the private duck club pond near Dirty Socks (USFWS 2009).
- Establish new populations of the Owens lineage. Recommended locations include but are not limited to the Owens Valley Native Fish Sanctuary (USFWS 2009).
- Improve habitat for existing populations at Little Hot Creek Pond, Owens Gorge, and Mule Spring. This improvement includes but is not limited to management/removal of nonnative aquatic floral and faunal species. For the Upper Owens Gorge population, increase the availability of lacustrine habitat and provide for adequate water quality and quantity throughout the year (USFWS 2009).
- Remove nonnative aquatic species (USFWS 2009).
- Conduct additional research to gain a better understanding of the origin, genetics, and ecophysiology of the Toikona lineage of the Owens tui chub. This information will help determine the best ways to conserve the unique attributes of this lineage (USFWS 2009).
- Develop and implement an education and outreach program for residents of, and visitors to, the Owens and Mono basins. The program would focus on the importance of conserving the native fish species, including the Owens tui chub, and the deleterious effects of nonnative predatory fish species. It would involve residents and visitors, adults and children, in ways they can help conserve the Owens tui chub (USFWS 2009).
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Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS In the 2021 CDFW Status Review (Section VI (B) – Recommendations for Management Activities and Other Recommendations for Recovery of the Species), CDFW provides a number of recommendations which we hereby incorporate and recommend as the highest priority actions needed for the recovery of this species. These and an additional recommendation from the Service are discussed below. CDFW recommendations The CDFW Status Review (2021) outlined the following recovery recommendations, which we hereby adopt: • Maintain existing habitats by performing ongoing habitat maintenance and emergent vegetation control and establishing partnerships with other agencies to ensure all refuge populations and their habitats are appropriately monitored; • Develop a genetics management plan, including conducting research as needed to inform the plan with up-to-date genetic information. Use the plan to develop and direct future population mixing or establishment of new populations in refuge sites; and • Evaluate new habitats for potential to support Owens tui chub and protect their genetic integrity. If one or more suitable habitats is/are identified, establish a new population/s in accordance with the genetics management plan, and develop a monitoring plan. Additional Service recommendation We believe that the recovery criteria outlined in the 1998 Recovery Plan (Service 1998) need to be updated to address threats from disease; catastrophic events; demographic, genetic and environmental stochasticity; and climate change. Developing recovery benchmarks based on current threats to the species, as well as the conservation biology principles of the three Rs (resiliency, redundancy, and representation) and the best available science, will accurately reflect species recovery needs. Furthermore, the designated Conservation Areas may need to be reassessed based on climate resiliency and ability to accommodate self-sustaining Owens tui chub populations indefinitely (USFWS, 2022).

Additional Threshold Information:

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SPECIES ACCOUNT: *Gila bicolor ssp.* (Big Smoky Valley tui chub)

Species Taxonomic and Listing Information

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Dispersal/Migration

Population Information and Trends

Threats and Stressors

Recovery

References

SPECIES ACCOUNT: *Gila cypha* (Humpback chub)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; March 11, 1967 (32 FR 4001). Reclassified to Threatened; November 17, 2021.

Physical Description

The humpback chub has a pronounced hump that rises above the gills and extends to the origin of the dorsal fin. It has a flattened, concave head; small eyes; subterminal, beak-like mouth; a long snout that protrudes over the lower jaw; and large fins. It is grey or olive colored on its back, with silver sides and a white belly. During the spawning season, adults develop rosy-red fins and gill coverings (USFWS 2014). Adults attain a maximum size of about 480 millimeters (mm) (19 inches [in.]) in total length and 1.2 kilograms (2.6 pounds) in weight (USFWS 2002).

Taxonomy

The humpback chub is a member of the Cyprinidae family and is distinguishable from other chubs by its pronounced hump (USFWS 2014). The Gila genus consists of six chub species that inhabit the Colorado River Basin and includes the humpback, roundtail, bonytail, Virgin River, Pahranagat roundtail, and Gila chubs (USFWS 2002).

Historical Range

The known historic distribution of the humpback chub includes portions of the mainstem Colorado River and four of its tributaries: the Green, Yampa, White, and Little Colorado rivers, spanning Utah, Colorado, Arizona, Nevada, and California. However, its original distribution throughout the Colorado River basin is not known with certainty. Before the 1940s, there was considerable manmade alteration occurring along the Colorado River, and there is some speculation that there may have been humpback chub populations in some river reaches of the Lower Colorado River Basin, although no documentation exists to confirm this (USFWS 2014).

Current Range

The humpback chub is found only in the Little Colorado River and adjacent portions of the Colorado River, primarily in Arizona. (USFWS 2014).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 3/21/1994.

Legal Description

On March 21, 1994, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Gila cypha (Humpback chub) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes seven critical habitat units (CHUs) in Arizona, Colorado, and Utah (59 FR 13374-13400).

The critical habitat designation for Gila cypha includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Gila cypha.

Critical Habitat Designation

The critical habitat designation for Gila cypha includes seven CHUs in Coconino County, Arizona; Mesa and Moffat Counties, Colorado; and Uintah, San Juan, Garfield and Grand, Counties, Utah (59 FR 13374-13400).

Unit 1—Colorado: Moffat County. The Yampa River from the boundary of Dinosaur National Monument in T.6N., R.99W., sec. 27 (6th Principal Meridian) to the confluence with the Green River in T.7N., R.103W., sec. 28 (6th Principal Meridian).

Unit 2—Utah: Uintah County; and Colorado: Moffat County. The Green River from the confluence with the Yampa River in T.7N., R.103W., sec. 28 (6th Principal Meridian) to the southern boundary of Dinosaur National Monument in T.6N., R.24E., sec. 30 (Salt Lake Meridian).

Unit 3—Utah: Uintah and Grand Counties. The Green River (Desolation and Gray Canyons) from Sumner's Amphitheater in T.12S., R.18E., sec. 5 (Salt Lake Meridian) to Swasey's Rapid in T.20S., R.16E., sec. 3 (Salt Lake Meridian).

Unit 4—Utah: Grand County; and Colorado: Mesa County. The Colorado River from Black Rocks in T.IOS., R.104W., sec. 25 (6th Principal Meridian) to Fish Ford River in T.21S., R.24E., sec. 35 (Salt Lake Meridian).

Unit 5—Utah: Garfield and San Juan Counties. The Colorado River from Brown Betty Rapid River in T.30S., R.18E., sec. 34 (Salt Lake Meridian) to Imperial Canyon in T.31S., R.17E., sec. 28 (Salt Lake Meridian).

Unit 6—Arizona: Coconino County. The Little Colorado River from river mile 8 in T.32N., R.6E., sec. 12 (Salt and Gila River Meridian) to the confluence with the Colorado River inT.32N., R.5E., sec. 1 (Salt and Gila River Meridian).

Unit 7—Arizona: Coconino County. The Colorado River from Nautiloid Canyon in T.36N., R.5E., sec. 35 (Salt and Gila River Meridian) to Granite Park in T.30N., RIOW., sec. 25 (Salt and Gila River Meridian).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Gila cypha critical habitat consists of three components (59 FR 13374-13400):

(1) Water: This includes a quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species.

(2) Physical Habitat: This includes areas of the Colorado River system that are inhabited or potentially habitable by fish for use in spawning, nursery, feeding, and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100- year flood plain, which when inundated provide spawning, nursery, feeding and rearing habitats, or access to these habitats.

(3) Biological Environment: Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although considered normal components of this environment, are out of balance due to introduced nonnative fish species in many areas.

Life History

Feeding Narrative

Juvenile: See Adult narrative.

Adult: Humpback chubs are opportunistic omnivores that feed on widely-distributed planktonic crustaceans and algae. The humpback chub's long snout and beak-like mouth may allow the fish to feed without the mouth becoming filled with rushing water (USFWS 2014). They face resource competition from nonnative fish, including smallmouth bass (Micropterus dolomieu). Their movements are relatively limited; a recapture and radio telemetry study found that they traveled on average less than 1.6 km (1 mi.)(NatureServe 2015). Juveniles reach 15 to 20 cm (5.9 to 7.8 in.) in total length by 3 years of age; adults reach 20 cm (7.9 in.) in total length by 4 years of age (USFWS 2002).

Reproduction Narrative

Juvenile: See Adult narrative.

Adult: Humpback chub are broadcast spawners that reach sexual maturity between 2 and 3 years of age and can live up to 30 years (USFWS 2014). Spawning occurs from May to July, when water temperatures are between 14 and 24° C (57 and 75° F) (USFWS 2014). Spawning occurs at depths ranging from 1.8 to 3.8 m (5.9 to 12.5 ft.) and water velocities of 0.15 to 0.30 m per second (0.49 to 0.98 ft. per second) over boulder, sand, and possibly gravel substrates (USFWS 2014). Abrasions on anal and lower caudal fins of males and females suggest that spawning involves rigorous contact with gravel substrates, although actual spawning events have not been observed (USFWS 2002). Egg incubation time is 3 days, and hatching success is temperature-dependent, with the greatest hatching success occurring at 20 °C (68 °F; USFWS 2014). Humpback chub have relatively low fecundity for broadcast spawners; female humpback chub injected with carp pituitary and stripped in a hatchery produced an average of 2,523 eggs each (USFWS 2002). Humpback chub display no parental care of young, which is typical of broadcast spawners. Sex ratios have been measured ranging from 41:59 to 58:42 (USFWS 2002).

Geographic or Habitat Restraints or Barriers

Juvenile: Dams and natural river barriers.

Adult: Dams and natural river barriers.

Spatial Arrangements of the Population

Juvenile: Random, able to use wide variety of riverine habitats.

Adult: Random, able to use wide variety of riverine habitats.

Environmental Specificity

Juvenile: Broad/generalist.

Adult: Broad/generalist.

Site Fidelity

Juvenile: High

Adult: High

Habitat Narrative

Juvenile: See Adult narrative.

Adult: Humpback chubs inhabit the Colorado River and its tributaries. Juvenile humpback chubs prefer low-velocity shoreline habitats, including eddies and backwaters, that are more prevalent under base-flow conditions; adults prefer eddies and sheltered shoreline habitats maintained by high spring flows (USFWS 2002). Both adults and juveniles are able to inhabit a wide variety of habitats, ranging from pools with turbulent to little or no current; substrates of silt, sand, boulder, or bedrock; and depths ranging from 1 m (3.3 ft.) to as deep as 15 m (49.2 ft.). Some areas of the Colorado River are turbulent. It is believed that the humpback chubs' humps cause them to be pushed to the bottom, where water velocities are lower and the chubs can hold their position without exerting excess energy (USFWS 2014). Humpback chubs’ distribution is limited by dams and natural river barriers, and their habitat in the Colorado River has been degraded by streamflow regulation and habitat modification.

Dispersal/Migration

Motility/Mobility

Juvenile: Moderate, able to move to and use diverse habitat types.

Adult: Moderate, able to move to and use diverse habitat types.

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Nonmigratory

Adult: Nonmigratory

Dispersal

Juvenile: Low

Adult: Low

Immigration/Emigration

Juvenile: Unlikely

Adult: Unlikely

Dependency on Other Individuals or Species for Dispersal

Juvenile: No

Adult: No

Dispersal/Migration Narrative

Juvenile: Larvae swim up about 3 days after hatching, but tend to remain close to spawning sites (USFWS 2002).

Adult: Humpback chubs are able to move locally between a diverse range of habitat types. However, they tend to have limited dispersal. One study found that, on average, individuals moved less than 1.6 km (1 mi.)(NatureServe 2015). Their movement appears to be particularly limited from summer through winter (NatureServe 2015).

Additional Life History Information

Juvenile: Larvae swim up about 3 days after hatching, but tend to remain close to spawning sites (USFWS 2002).

Adult: The movement of humpback chubs is limited; one study found that, on average, individuals moved less than 1.6 km (1 mi.). Movement appears to be particularly limited from summer through winter (NatureServe 2015).

Population Information and Trends

Population Trends:

Variable; some populations are declining, while others are stable (USFWS 2011).

Species Trends:

Declining (USFWS 2011)

Resiliency:

Humpback chub have many traits that enable individuals to be resilient in the face of environmental or demographic stochasticity including long life span, high reproductive potential, use of habitats and turbidity that are arduous to other species, adaptation to a wide variety of flow and thermal regimes, and a variable omnivorous diet. Population resiliency is demonstrated by a variety of traits including persistence of small populations (Cataract Canyon), population increases over many years of decline (Grand Canyon), increases after translocations (Havasu Creek), and potential stabilization of declines (Black Rocks and Westwater Canyon). In addition, the current population size of the Grand Canyon protects it from a variety of potential threats (USFWS, 2018).

Representation:

The current distribution of the Humpback Chub provides a sufficient level of redundancy, albeit at a near-minimal level. Existing populations have independent susceptibility to threats by occurring in different river basins. New populations are being discovered (western Grand Canyon) or established (Havasu Creek) in the lower basin, and are being considered (Dinosaur National Monument) in the upper basin. This redundancy also assists with representation, as all genetic diversity of the species occurs in multiple populations, except the very large Grand Canyon population. In the upper basin, exchange of individuals is sufficient to ensure genetic diversity (USFWS, 2018).

Redundancy:

The current distribution of the Humpback Chub provides a sufficient level of redundancy, albeit at a near-minimal level. Existing populations have independent susceptibility to threats by occurring in different river basins. New populations are being discovered (western Grand Canyon) or established (Havasu Creek) in the lower basin, and are being considered (Dinosaur National Monument) in the upper basin. This redundancy also assists with representation, as all genetic diversity of the species occurs in multiple populations, except the very large Grand Canyon population. In the upper basin, exchange of individuals is sufficient to ensure genetic diversity (USFWS, 2018).

Population Growth Rate:

Declining

Number of Populations:

6

Population Size:

Roughly 10,000 (USFWS 2011).

Minimum Viable Population Size:

2,100 (USFWS 2002)

Resistance to Disease:

Low

Additional Population-level Information:

None

Population Narrative:

The species currently occupies about 68 percent of its historic habitat of about 756 km (470 mi.) of river. Six self-sustaining populations of humpback chub are known to exist. Five of the populations occur in the upper basin recovery unit: 1) Black Rocks, Colorado River, Colorado; 2) Westwater Canyon, Colorado River, Utah; 3) Yampa Canyon, Yampa River, Colorado; 4) Desolation/Gray canyons, Green River, Utah; and 5) Cataract Canyon, Colorado River, Utah. The only population in the lower basin recovery unit occurs in the mainstem Colorado River in Marble and Grand canyons and the Lower Colorado River, Arizona. In the upper basin recovery unit, there has been a significant decline in adult abundance at three locations and poor juvenile recruitment at all locations. Therefore, these populations are not considered self-sustaining. In the lower basin recovery unit, the adult population was in decline between 1989 and 2000, but began to recover between 2001 and 2008. The stability of the juvenile population in the lower basin recovery unit is unclear, but the overall population is considered self-sustaining (USFWS 2011).

Threats and Stressors

Stressor: Construction of dams, streamflow regulation
Exposure: Habitat loss and modification.
Response: Reduced quality and quantity of habitat, reduced dispersal ability.
Consequence: Less available habitat for humpback chub populations, reduced potential for gene flow.
Narrative: The construction and operation of Flaming Gorge, Glen Canyon, and Hoover dams have eliminated or altered portions of this species habitat and blocked migration routes (USFWS 2014). Streamflow regulation and associated habitat modification are the primary threats to humpback chub populations. Reservoir inundation, cold-water releases from dams, streamflow alteration, changes in channel geomorphology, and modification of sediment transport have impacted habitat of the native Colorado River fishes, including the humpback chub (USFWS 2011).

Stressor: Competition and predation by introduced species
Exposure: Nonnative competitors and predators.
Response: Reduced food availability and predation.
Consequence: Declining populations of humpback chub.
Narrative: Competition and predation by introduced species has been a factor in the decline of the humpback chub. The threat of predation by nonnative fishes on humpback chub has been recognized in two populations in the upper basin. Channel catfish (Ictalurus punctatus) are the principal predator of humpback chub in Desolation/Gray canyons and Yampa Canyon (USFWS 2011).

Stressor: Pollution and pesticides
Exposure: Pollution and pesticides.
Response: Potential deformities or mortality of humpback chub.
Consequence: Increased rates of deformities and/or declining populations of humpback chub.
Narrative: Humpback chub living in habitats with high pollution or pesticide levels have been found to have spinal deformities, although there are no data showing a direct correlation between the pollution or pesticide levels and individual deformities (USFWS 2014).

Recovery

Reclassification Criteria:
Downlisting can occur if, over a 5-year period:

The trend in adult (age 4+; =200 mm [7.9 in.] total length) point estimates for each of the six extant populations does not decline significantly (USFWS 2002).

Mean estimated recruitment of age-3 (150 to 199 mm [5.9 to 7.8 in.] total length) naturally produced fish equals or exceeds mean annual adult mortality for each of the six extant populations (USFWS 2002).

Two genetically and demographically viable, self-sustaining core populations are maintained, so that each point estimate for each core population exceeds 2,100 adults (2,100 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability) (USFWS 2002).

When certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented (USFWS 2002).

Recommended Classification: After assessing the best available information, we conclude that the Humpback Chub is not in danger of extinction throughout all of its range, but is likely to become so in the foreseeable future; that is, it is a threatened species throughout all of its range. We recommend downlisting the Humpback Chub to threatened status (USFWS, 2018).

Reclassification (from Endangered to Threatened) Priority Number: 2C. (USFWS, 2018).

Delisting Criteria:
Delisting can occur if, over a 3-year period beyond downlisting:

The trend in adult point estimates for each of the six extant populations does not decline significantly (USFWS 2002).

Mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the six extant populations (USFWS 2002).

Three genetically and demographically viable, self-sustaining core populations are maintained, so that each point estimate for each core population exceeds 2,100 adults (USFWS 2002).

When certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained (USFWS 2002).

Recovery Actions:
- Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations (USFWS 2002).
- Investigate the role of the mainstem Colorado River in maintaining the Grand Canyon population (USFWS 2002).
- Investigate the anticipated effects of and options for providing warmer water temperatures in the mainstem Colorado River through Grand Canyon (USFWS 2002).
- Ensure adequate protection from overuse (USFWS 2002).
- Ensure adequate protection from diseases and parasites (USFWS 2002).
- Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries (USFWS 2002).
- Control problematic nonnative fishes as needed (USFWS 2002).
- Minimize the risk of increased hybridization among Gila spp. (USFWS 2002).
- Minimize the risk of hazardous-materials spills in critical habitat (USFWS 2002).

- Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans) (USFWS 2002).
-

Additional Threshold Information:

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USFWS. 2018. Humpback Chub (Gila cypha) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Mountain-Prairie Region Lakewood, Colorado. 15 pp.

SPECIES ACCOUNT: *Gila ditaenia* (Sonora chub)

Species Taxonomic and Listing Information

Listing Status: Threatened; 4/30/1986 (51 FR 16042).

Physical Description

The Sonora chub is a medium-sized (approximately 125 millimeters [5 inches] in length), moderately chubby, dark-colored fish that has two distinct black, lateral bands above the lateral line and a dark oval spot at the base of the tail (51 FR 16042; USFWS 2013). In breeding males, a red coloration develops at the bases of the lower fins, and some orange coloration is present on the belly (51 FR 16042).

Taxonomy

The Sonora chub is a member of the minnow family Cyprinidae (USFWS 2013). Its subgenus is Temeculina, which also includes the Yaqui chub (Gila purpurea), arroyo chub (Gila orcutti), and desert chub (Gila eremica) (USFWS 1992). Its primary distinguishing characteristic from other members of the Temeculina subgenus is the round spot at the base of its tail.

Historical Range

The Sonora chub is native to southeastern Arizona and northern Mexico. Its historical distribution includes Sycamore Canyon and California Gulch in the United States, and the Rio de Concepción drainage in Mexico (USFWS 2013).

Current Range

The Sonora chub continues to inhabit its known historical range in Sycamore Canyon and California Gulch in the United States, and the Rio de Concepción drainage in Mexico (USFWS 2013).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 4/30/1986.

Legal Description

On April 30, 1986, the Service determined crtitical habitat for Gila ditaenia (Sonora chub) under the authority contained in the Endangered Species Act of 1973, as amended, in Santa Cruz County, Arizona.

Critical Habitat Designation

The critical habitat designation for Gila ditaenia includes four units in the Coronado National Forest, Santa Cruz County, Arizona.

1. Sycamore Creek, and a riparian zone 25 feet wide along each side of the creek, from Yank's Spring downstream approximately 5 stream miles to the International Border with Mexico within sections 14, 22, 23, 27, 33, and 34. T. 23 S.; R. 11 E.

2. Yank's Spring in the SE1/4 of the NW1/4 of sec. 14. T. 23 S.; R. 11 E.

3. Penasco Creek, including a riparian zone 25 feet wide along each side of the creek, from its confluence with Sycamore Creek (SW1/4 of the SW1/4 of sec. 23, T. 23 S.; R. 11 E.) upstream approximately 1.25 miles to the east boundary of sec. 26. T. 23 S.;

4. An unnamed tributary to Sycamore Creek, from its confluence with Sycamore Creek (SW1/4 of the NW1/4 of sec. 23. T. 23 S.; R. 11 E.) upstream approximately 1/4 mile to the west boundary of the NE1/4 of the SE1/4 of the NE1/4 sec. 22. T. 23 S.; R. 11 E.

Primary Constituent Elements/Physical or Biological Features

Known primary constituent elements include:

clean permanent water with pools and intermediate riffle areas and/or intermittent pools maintained by bedrock or by subsurface flow in areas shaded by canyon walls.

Special Management Considerations or Protections

Present management of these areas is compatible with the critical habitat designation.

Life History

Feeding Narrative

Juvenile: See Adult narrative.

Adult: Sonora chub are opportunistic omnivores; adults feed on aquatic and terrestrial invertebrates and algae, and juveniles feed on microscopic organisms and algae. They experience resource competition from nonnative fish, particularly bluegill (Lepomis macrochirus) and largemouth bass (Micropterus salmoides) (USFWS 2013).

Reproduction Narrative

Juvenile: See Adult narrative.

Adult: Sonora chub are oviporous spawners that deposit their eggs onto fine gravel substrates in slowly flowing water. Spawning occurs multiple times during spring and summer, and is likely triggered by floods or freshets that occur after spring and summer rains. Once eggs are deposited, there is no parental care of eggs or juvenile fish (USFWS 2013).

Geographic or Habitat Restraints or Barriers

Adult: Dams lacking suitable fishways, high waterfalls (NatureServe 2015).

Spatial Arrangements of the Population

Juvenile: Random; juveniles more likely to use shallow habitats and pool margins.

Adult: Random; adults more likely to use deep pools, riffles, and runs.

Environmental Specificity

Juvenile: Broad/generalist

Adult: Broad/generalist

Tolerance Ranges/Thresholds

Adult: High; able to exploit small, marginal habitats, and can survive under severe environmental and hydrologic conditions present in Sycamore Canyon and California Gulch.

Site Fidelity

Juvenile: High

Adult: High

Habitat Narrative

Juvenile: See Adult narrative.

Adult: Sonora chub inhabit riverine environments and are commonly found in pools created by cliffs, boulders, or other cover in intermittent stream channels. Juveniles likely use shallow habitats and pools margins; adults use deep pools, riffles, and runs. Although they prefer to occupy riverine habitat, they are often confined in small, marginal habitats, and can survive under severe environmental and hydrologic conditions present in Sycamore Canyon and California Gulch. In lotic waters in Mexico, Sonora chub have been commonly found in pools less than 0.6 m (2 ft.) deep adjacent to or near areas with a fairly swift current. They have been less commonly found in reaches that are predominantly pools with low velocities and organic sediments. Their dispersal is restricted by dams lacking suitable fishways and high waterfalls, and their habitat is moderately degraded due to mining, grazing, construction, and other human activity (NatureServe 2015, USFWS 2013).

Dispersal/Migration

Motility/Mobility

Juvenile: High; able to maneuver upstream past small waterfalls and other obstructions to colonize newly wetted habitats (USFWS 2013).

Adult: High; able to maneuver upstream past small waterfalls and other obstructions to colonize newly wetted habitats (USFWS 2013).

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Nonmigratory

Adult: Nonmigratory

Dispersal

Juvenile: Moderate

Adult: Moderate

Immigration/Emigration

Juvenile: Emigrates

Adult: Emigrates

Dependency on Other Individuals or Species for Dispersal

Juvenile: No

Adult: No

Dispersal/Migration Narrative

Juvenile: See Adult narrative.

Adult: The chub is restricted to one river system; as noted, it is able to move through the system when flows are suitable (NatureServe 2015). Sonora chub are able to move locally and maneuver upstream past small waterfalls and other obstructions to colonize newly wetted habitats (USFWS 2013). Though they have high dispersal ability, they are nonmigratory.

Population Information and Trends

Population Trends:

Unknown; "There are no data to indicate that Sonora chub numbers are increasing nor decreasing in abundance in the wild within the United States…" (USFWS 2013).

Species Trends:

Unknown; "There are no data to indicate that Sonora chub numbers are increasing nor decreasing in abundance in the wild within the United States…" (USFWS 2013).

Population Growth Rate:

Unknown; likely stable or slowly declining (NatureServe 2015).

Number of Populations:

There are approximately 10 subpopulations in the United States and Mexico (NatureServe 2015).

Population Size:

Unknown; "Total adult population size is unknown" (NatureServe 2015).

Resistance to Disease:

Low

Additional Population-level Information:

None

Population Narrative:

The Sonora chub occurs in three rivers in the Rio de Concepción drainage in Sonora, Mexico (Rio Altar, Rio de la Concepción, and Rio Cocospera on the Ranch el Aribabi); and in two locations in Santa Cruz County, Arizona (California Gulch and Sycamore Canyon). There are approximately 10 subpopulations in these locations in southeastern Arizona and northern Mexico. The stability and trends of the populations and of the species overall is unknown, although it is thought that the species is likely stable or slowly declining. The total adult population size is unknown

(NatureServe 2015). The AGFD reports on Sonora chub presence at more frequent but irregular intervals. Sonora chub were noted in Sycamore Canyon in 2007 (Nate Berg pers. comm. 2022). Sonora chub were detected in three pools at Casita Spring (protected spring run that feeds into Sycamore Canyon near the Mexican border) in 2017 (Hunter McCall pers. comm. 2017). Sonora chub were noted in Sycamore Canyon- one of the species' mainstem habitats in the United States - on site visits in 2019 and 2022 (Elizabeth Grube pers. comm. 2022a), but fish were absent from dry reaches of Peñasco Canyon and an unnamed tributary (Elizabeth Grube pers. comm. 2022b). No Sonora chub were detected in sampling of California Gulch in June of 2022, although the pools sampled by AGFD may have only recently become inundated by rains (Elizabeth Grube pers. comm. 2022b). International border security issues were noted by AGFD as further complicating efforts to monitor populations of Sonora chub. Service staff have also reported on the presence of Sonora chub. Numerous individuals were noted in a large pool in Sycamore Canyon in May 2014 (Cat Crawford pers. comm. 2014a) and at a Tarahumara frog (Lithobates tarahumarae) release site, also in Sycamore Canyon, in October 2014 (Cat Crawford pers. comm. 2014ba). Post-2013 detection data for Sonora chub in Mexico also exists. A 2015 collection from the Rio Cocospera at Rancho El Aribabi in Sonora (Doug Duncan pers. comm. 2022 and James Rorabaugh pers. comm. 2022) was the source of the cover photograph to this document. Sonora chub was again detected in the Rio Cocospera in 2017, in two Rio Cocospera locations in 2022, and in the Rio Bambuto in 2022 (Doug Duncan pers. comm. 2022). It is likely border security issues confound Sonora chub survey efforts south of the International Boundary as they do along the border in Arizona (USFWS, 2022).

Threats and Stressors

Stressor: Mining
Exposure: Water development, changes in water use, reduced water quality, introduction of pollutants related to mining activity.
Response: Potential for a large mortality event of Sonora chub.
Consequence: Population decline or extirpation of a population.
Narrative: Water development, including water use and impacts to water quality from mines, has been described as a threat to the Sonora chub. The threat from mining and mine discharge is moderate for the Sonora chub, given the limited locations in which the chub occurs and the potential for toxicity that could take numerous fish at once (USFWS 2003).

Stressor: Grazing
Exposure: Increased runoff and changes in sediment transport, due to livestock grazing.
Response: Degradation of water quality and introduction of pollutants.
Consequence: Decreased fitness or mortality of Sonora chub.
Narrative: Adverse impacts to Sonora chub associated with cattle grazing include the degradation, siltation, and water pollution caused primarily by livestock grazing in the riparian corridors. Livestock grazing activities can contribute to changes in surface runoff quality and intensity, sediment transport, and water holding capabilities in the watershed. The threat of livestock grazing remains moderate for the Sonora chub (USFWS 2003).

Stressor: Roads and Infrastructure
Exposure: Increased runoff and sedimentation, introduction of pollutants associated with construction.
Response: Degradation of water quality and introduction of pollutants.

Consequence: Decreased fitness or mortality of Sonora chub.
Narrative: Construction, maintenance, and heavy use of roads can displace or remove vegetation, disturb sediments, and introduce chemicals into the environment. Rain events shortly after construction can lead to elevated runoff and increased sedimentation in drainages, which in turn causes spikes in turbidity and pollutants. Given the high level of human activity near Sonora chub habitats, this threat is significant (USFWS 2003).

Stressor: Fire
Exposure: Increased ash and sediment in rivers inhabited by Sonora chub, due to fire.
Response: Degradation of water quality.
Consequence: Decreased fitness or mortality of Sonora chub.
Narrative: Fires can cause ash and sediment deposits in rivers inhabited by Sonora chub. The threat of fires continues to be severe, because there are only two known metapopulations in the United States. One severe fire or misplaced fire retardant drop could severely impact or possibly remove one of the populations; or significantly affect the species' genetic diversity and limit the potential recovery of the Sonora chub (USFWS 2003).

Stressor: Border Activities
Exposure: Ground disturbance due to border activities.
Response: Degradation of water quality, reduction in quantity of available habitat.
Consequence: Decreased fitness or mortality of Sonora chub.
Narrative: Illegal immigration and associated interdiction activities in Sycamore Canyon and California Gulch cause significant ground disturbance, which continues to pose a significant threat to the habitat of Sonora chub (USFWS 2003).

Stressor: Asian tapeworm
Exposure: Hybridization with Yaqui chub that have Asian tapeworm.
Response: Parasitism of Sonora chub by Asian tapeworm.
Consequence: Decreased fitness of Sonora chub.
Narrative: The presence of Asian tapeworm (Bothriocephalus acheilognathi) in the fishes of the Río Yaqui watershed—particularly the Yaqui chub (Gila purpurea)—is a threat to the Sonora chub, because the two species have the potential to hybridize. The likelihood that Sonora chub will be exposed to Asian tapeworm is high, but because exposure to this tapeworm does not result in mortality, the threat of Asian tapeworm to Sonora chub is low (USFWS 2003).

Stressor: Nonnative fishes
Exposure: Nonnative competitors and predators.
Response: Reduced food availability and increased predation.
Consequence: Declining populations of Sonora chub.
Narrative: Nonnative fishes have been present in the occupied Sonora chub habitat for years. Although the presence of nonnative fish increases the probability of exposure to Asian tapeworm, competition for resources, and the possibility of predation, Sonora chub have persisted in numbers great enough to recolonize California Gulch and survive in an environment where conditions are dynamic. The main threats posed by nonnative fish, particularly bluegill (Lepomis macrochirus) and largemouth bass (Micropterus salmoides), are competition and predation (USFWS 2003).

Stressor: Climate change

Exposure: Increased temperatures and frequency of drought.
Response: Reduction in available habitat.
Consequence: Declining populations of Sonora chub.
Narrative: Projections for the southwest include warmer, drier, and more drought-like conditions as a result of climate change. These changes are expected to reduce the amount of habitat available to the Sonora chub in the United States; worsen habitat conditions throughout the species' range; strengthen effects of other threats; and to have both direct and indirect ecological effects on the species. The effects of climate change, particularly those associated with drought and rising temperatures, have the potential to be a severe threat to the Sonora chub (USFWS 2003).

Recovery

Reclassification Criteria:
Recovery Priority Number: 2C (USFWS, 2022)

Delisting Criteria:
Delisting is unlikely to occur due to presence of nonnative species, degradation of habitat, and continued demand for water for human consumption (USFWS 2013). Need to develop delisting criteria.

Recovery Actions:

- Protect remaining populations of Sonora chub by recognizing critical habitat; removing nonnative fishes; determining water use patterns and protecting water rights; incorporating Sonora chub management needs into management plans for Goodding Research Natural Area and Pajarita Wilderness; ensuring habitat integrity; and surveying all existing and potential habitats (USFWS 2013).
- Monitor and assess population and habitat dynamics by establishing standardized monitoring techniques for fish and habitat; assessing population dynamics (including determining reproductive variables, effects of predation and competition, survivorship by age group, disease and parasites, diet of all life stages, seasonal and annual distribution of all life stages, and other factors pertinent to perpetuation of the Sonora chub); and assessing habitat dynamics (including determining fish-habitat relationships, determining precipitation-runoff relationships, and evaluating relationships of runoff-intstream flow needs) (USFWS 2013).
- Maintain captive reserves of Sonora chub by establishing captive reserve populations and determining the genetic variability of the species (USFWS 2013).
- Produce information for public education in the United States and Mexico by producing an information pamphlet, issuing news releases, developing and conducting interpretive programs, and providing status information for interested parties (USFWS 2013).
- Captive Population: The only known captive population of Sonora chub in the United States is at the Arizona-Sonora Desert Museum (ASDM). This refugium population, which the ASDM has maintained since 1988, is highly important in the preservation of the species because it will ensure persistence of the species in an environment where typical threats to the species do not apply, and allow for potential emergency conservation measures to be taken. The establishment of this captive population, and establishment of other captive populations if possible, is the greatest conservation measure taken to preserve the species since its listing (USFWS 2013).

- Consultations: Since 1990, the U.S. Fish and Wildlife Service has conducted approximately 42 interagency consultations and technical assistance efforts involving Sonora chub and/or the species' critical habitat (USFWS 2013).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The 2013 5-Year Review recommended a series of additional measures for implementation. We again recommend the same measures, which are as follows: • Develop, refine, and finalize a standardized survey protocol for the Sonora chub to provide a method for rigorous and repeatable species abundance surveys and determine population trends. • Systematically survey species and habitat to evaluate population and physical habitat trends should be established under the direction of the current recovery plan (Service 1992) and should be implemented throughout the species’ range in the U.S. and Mexico. • Conduct studies with a focus on ecological factors that influence distribution, densitydependence issues, resource requirements for survival, demographic trends, population biology, and the amount and condition of suitable habitat. • Model climate factors to a scale (i.e. the Río de La Concepción watershed) whereby changes in the biological and physical environment occupied by the Sonora chub can be ascertained. The uncertainty regarding climate change equates with an ecological risk to Sonora chub. • Lastly, strengthen cooperative relationships with agencies and organizations in Mexico to facilitate studies and future recovery planning and implementation efforts for the Sonora chub (USFWS, 2022).

Additional Threshold Information:

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SPECIES ACCOUNT: *Gila elegans* (Bonytail chub)

Species Taxonomic and Listing Information

Listing Status: Endangered; April 23, 1980; Mountain-Prairie Region (R6)

Physical Description

The bonytail (Gila elegans) is a large cyprinid fish endemic to the Colorado River Basin (Valdez and Clemmer 1982). Adults attain a maximum size of about 550 mm total length (TL; Bozek et al. 1984) and 1.1 kg in weight (Vanicek 1967).

Taxonomy

The bonytail is a member of a unique assemblage of fishes native to the Colorado River Basin consisting of 35 species with 74 percent level of endemism (Miller 1959). It is one of four mainstem, big-river fishes currently listed as endangered under the ESA; others are the humpback chub (Gila cypha), Colorado pikeminnow (Ptychocheilus lucius, formerly Colorado squawfish; Nelson et al. 1998), and razorback sucker (Xyrauchen texanus).

Historical Range

The bonytail was historically common to abundant in warm-water reaches of larger rivers from Mexico to Wyoming.

Current Range

U.S.: La Paz, Mohave, and Yuma counties, AZ; Mesa, Moffat, and Saguache counties, CO; Clark County, NV; 16 counties, UT. Currently, no self-sustaining populations of bonytail exist in the wild, and few individuals have been caught throughout the basin,

Distinct Population Segments Defined

No.

Critical Habitat Designated

Yes; 3/21/1994.

Legal Description

On March 21, 1994, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Gila elegans (Bonytail chub) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes seven habitat units (CHUs) in Arizona, California, Colorado, Nevada and Utah (59 FR 13374-13400).

The critical habitat designation for Gila elegans includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Gila elegans.

Critical Habitat Designation

The critical habitat designation for Gila elegans includes seven CHUs in Mohave County, Arizona; Clark County, Nevada; San Bernardino County, California; Mesa and Moffat Counties, Colorado; Garfield, Grand, San Juan and Uintah Counties, Utah (59 FR 13374-13400).

Unit 1—Colorado: Moffat County. The Yampa River from the boundary of Dinosaur National Monument in T.6N., R.99W., sec. 27 (6th Principal Meridian) to the confluence with the Green River in T.7N., R.103W., sec. 28 (6th Principal Meridian).

Unit 2—Utah: Uintah County; and Colorado, Moffat County. The Green River from the confluence with the Yampa River in T.7N., R.103W., sec. 28 (6th Principal Meridian) to the boundary of Dinosaur National Monument in T.6N., R24E., sec. 30 (Salt Lake Meridian).

Unit 3—Utah: Uintah and Grand Counties: The Green River (Desolation and Gray Canyons) from Sumner's Amphitheater inT.12S., R.18E., sec.5(Salt Lake Meridian) to Swasey's Rapid in T.20S., R.16E., sec. 3 (Salt Lake Meridian).

Unit 4—Utah: Grand County; and Colorado, Mesa County. The Colorado River from Black Rocks in T.1OS., R.104W., sec. 25 (6th Principal Meridian) to Fish Ford in T.21S., R.24E., sec. 35 (Salt Lake Meridian).

Unit 5—Utah: Garfield and San Juan Counties: The Colorado River from Brown Betty Rapid in T.30S., R.18E., sec. 34 (Salt Lake Meridian) to Imperial Canyon in T.31S., R.17E., sec. 28 (Salt Lake Meridian).

Unit 6—Arizona: Mohave County; Nevada: Clark County; and California: San Bernardino County. The Colorado River from Hoover Dam in T.30N., R.23W., sec. 3 (Gila and Salt River Meridian) to Davis Dam in T.21N., R.21W., sec. 18 (Gila and Salt River Meridian) including Lake Mohave up to its full pool elevation.

Unit 7—Arizona: Mohave County; and California: San Bernardino County. The Colorado River from the northern boundary of Havasu National Wildlife Refuge in R.22W., T.16N., sec. 1 (Gila arid Salt River Meridian) to Parker Dam in T.11N., R18W., sec. 16 (Gila and Salt River Meridian) including Lake Havasu up to its full pool elevation.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Gila elegans critical habitat consists of fifteen components in Arizona, California, Colorado, Nevada and Utah (59 FR 13374-13400):

(1) Water: This includes a quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species.

(2) Physical Habitat: This includes areas of the Colorado River system that are inhabited or potentially habitable by fish for use in spawning, nursery, feeding, and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100- year flood plain, which when inundated provide spawning, nursery, feeding and rearing habitats, or access to these habitats.

(3) Biological Environment: Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although considered normal components of this environment, are out of balance due to introduced nonnative fish species in many areas.

(4) Presence of known or suspected wild spawning populations, although recruitment may be limited or nonexistent.

(5) Areas where juvenile razorback suckers have been collected or which could provide suitable nursery habitat (backwaters, flooded bottom lands, or coves).

(6) Areas presently occupied or that were historically occupied that are considered necessary for recovery and that have the potential for reestablishment of razorback suckers.

(7) Areas and water required to maintain range-wide fish distribution and diversity under a variety of physical, chemical, and biological conditions.

(8) Areas that need special management or protection to insure razorback survival and recovery. These areas once met the habitat needs of the razorback sucker and may be recoverable with additional protection and management.

Life History

Feeding Narrative

Juvenile: In riverine habitat, small juvenile chubs primarily eat chironomid larvae and mayfly nymphs (FWS 1990). Older juvenile chubs diet includes terrestrial insects and gastropods (FWS 1990). Whereas, in resevoir habitat their diet appears to primarily consist of plankton and algae, although rainbow trout fry smaller than 63.5 mm have been found in the stomach of bonytail chubs in Lake Mojave (FWS 1990).

Adult: Older juvenile and adult chubs diet includes terrestrial insects and gastropods (FWS 1990). Whereas, in resevoir habitat their diet appears to primarily consist of plankton and algae, although rainbow trout fry smaller than 63.5 mm have been found in the stomach of bonytail chubs in Lake Mojave (FWS 1990).

Reproduction Narrative

Adult: Natural reproduction of bonytail was last documented in the Green River in Dinosaur National Monument in the 1960s (Vanicek and Kramer 1969). Bonytails in reproductive condition were captured from mid-June to early July at a water temperature of 18°C. Spawning in Lake Mohave was observed in May (Jonez and Sumner 1954). Hamman (1985) found that hatchery-reared bonytails began to sexually mature at age 2. Bonytails can mature within one year in artificial ponds (Minckley and Marsh 2009). Examination of otoliths from four bonytails from Lake Mohave indicated ages of 34, 40, 42, and 49 years (Rinne et al. 1986). Spawning in reservoirs begins in late spring or early summer (FWS 1990) when temperatures reach approximately 18°C (FWS 1980). During spawning, bonytail chub congregate over gravel bars (FWS 1990), rocky shoals, and shorelines (FWS 2002) in up to 9 meters of water (FWS 1990). Eggs are randomly deposited and there appears to be no parental care after spawning with adutlt chub dispersing after laying eggs (FWS 1990). Numerous reports exists documenting the predation of native fish eggs and larvae by non-native fish species (Marsh and Langhorst 1988, Langhorst 1989). Studies have shown that survival and growth is increased in bonytail population in the absence of predators (FWS 2002). Spawning in riverine habitat, begins in the spring over rocky substrates (FWS 2002) when temperatures reach approximately 18°C (FWS 1980). Spring peak flows cleanse rocky substrates of fine sediments that can smother eggs (FWS 2002). In addition to cleansing rocky substrates, high spring flows can limit predation of bonytail chub eggs and larvae by non-native fish species by displacing them, interupting their spawning, and possibly through direct mortality (FWS 2002). Numerous reports exists documenting the predation of native fish eggs and larvae by non-native fish species (Marsh and Langhorst 1988, Langhorst 1989). Studies have shown that survival and growth is increased in bonytail population in the absence of predators (FWS 2002).

Geographic or Habitat Restraints or Barriers

Adult: Dams lacking a suitable fishway; high waterfall; upland habitat

Habitat Narrative

Egg: In riverine habitat, bonytail chub spawn in the spring over rocky substrates (FWS 2002) when temperatures reach approximately 18°C (FWS 1980). Spring peak flows cleanse rocky substrates of fine sediments that can smother eggs (FWS 2002). In addition to cleansing rocky substrates, high spring flows can limit predation of bonytail chub eggs and larvae by non-native fish species by displacing them, interupting their spawning, and possibly through direct mortality (FWS 2002). Numerous reports exists documenting the predation of native fish eggs and larvae by non-native fish species (Marsh and Langhorst 1988, Langhorst 1989). Studies have shown that survival and growth is increased in bonytail population in the absence of predators (FWS 2002). Cold water releases from dams have caused reproductive failure and slowed growth of warm-water native fishes (FWS2002). Research conducted at a fish hatchery shows that eggs incubated at = 13°C only had a 4% survival rate, while eggs incubated at 16 - 21°C had a survival rate that ranged between 55 - 90% (Hamman 1982, FWS 1990). No eggs hatch at temperatures =10°C or =30°C (Marsh 1985). Cold water releases from dams have caused reproductive failure and slowed growth of warm-water native fishes (FWS2002). Research conducted at a fish hatchery shows that eggs incubated at = 13°C only had a 4% survival rate, while eggs incubated at 16 - 21°C had a survival rate that ranged between 55 - 90% (Hamman 1982, FWS 1990). No eggs hatch at temperatures =10°C or =30°C (Marsh 1985).

Juvenile: Flooded bottomlands are important habitat for the growth and conditioning of juvenile bonytail chub (FWS 2002). These areas provide young chubs plenty of prey resources and acts as a refuge from predators. Relatively low, stable base flows that occur in riverine habitat in the summer, winter, and fall provide for stable, warm and productive nursery habitats for young fish (FWS 2002). It is believed that predation by non-native species are a major factor in the lack of recruitment of native fish, including the bonytail (Tyus 1987, Minckley 1991, FWS 2002), and studies have shown that survival and growth is increased in bonytail population in the absence of predators (FWS 2002).

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant

Dispersal

Adult: Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats.

Immigration/Emigration

Adult: No.

Population Information and Trends

Population Trends:

Unknown

Species Trends:

Declining

Population Growth Rate:

Unknown

Number of Populations:

Unknown

Population Size:

Unknown

Minimum Viable Population Size:

4,400 individuals

Resistance to Disease:

Unknown

Adaptability:

Unknown

Population Narrative:

Currently (USFWS 2002), no self-sustaining populations of bonytail exist in the wild, and very few individuals have been caught throughout the basin. Captures of wild adult bonytail have occurred in Lakes Powell, Mohave, and Havasu, and in rivers of the Upper Colorado River Basin. Of the 34 adult bonytail captured in Lake Mohave between 1976 and 1988 (Minckley et al. 1989), 11 were used as the original brood stock (Hamman 1981, 1982, 1985). Progeny of these fish have been released into several locations in upper and lower basin habitats, with variable survival rates. Approximately 130,000 hatchery-produced F1 and F2 fish were released into Lake Mohave between 1981 and 1987 as part of an effort by the Service to prevent extinction and promote eventual recovery of the species. Younger bonytail of adult size and spawning ability have been collected from the reservoir in the 1990's along with the old adults of the founder population. It is unknown whether these younger adults are from the original stockings or a result of natural reproduction. Releases of hatchery-reared adults into riverine reaches in the upper basin have resulted in low survival (Chart and Cranney 1991), with no evidence of reproduction or recruitment. Recent releases into repatriated, predator-free riverside ponds near Parker, Arizona, have produced up to three year classes (Pacey and Marsh 1998; personal communication, C. Minckley, U.S. Fish and Wildlife Service). Since 1977, only 11 wild adults have been reported from the upper basin (Valdez et al. 1994), but no upper basin fish have been transferred to hatchery facilities. Releases of hatchery-reared bonytails have not resulted in definite reproduction in the wild or population recruitment. Approximately 130,000 hatchery-produced F1 and F2 fishes were released into Lake Mohave between 1981 and 1987 as part of an effort by the USFWS to prevent extinction and promote eventual recovery of the species. Younger bonytail of adult size and spawning ability were collected from the reservoir in the 1990s along with the old adults of the founder population. It is unknown whether these younger adults are from the original stockings or a result of natural reproduction (USFWS 2002). Releases of hatchery-reared adults into riverine reaches in the upper basin have resulted in low survival (Chart and Cranney 1991), with no evidence of reproduction or recruitment (USFWS 2002). While recent findings yield interesting results for the species, the fact remains that bonytail are extremely rare in the wild (USFWS, 2024).

Threats and Stressors

Stressor: Habitat alterations
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Historical habitat alterations led to a loss of the contiguous complement of habitats used by the various life history phases of the species. Hence, streamflow regulation and associated habitat modification are identified as primary threats to the bonytail. Regulation of streamflows in the Colorado River Basin is manifested as reservoir inundation of riverine habitats and changes in flow patterns, sediment loads, and water temperatures. For example, streamflow regulation has generally reduced the magnitude of spring peak flows and increased the magnitude of summer–winter base flows. Since 1950, annual peak flows of the Colorado River in historic upper Colorado River habitats have decreased by 29 to 38 percent (Van Steeter and Pitlick 1998). Flows of the Green River at Jensen, Utah, have decreased by 13 to 35 percent during spring and increased by 10–140% during summer through winter due to regulation by Flaming Gorge Dam (Muth et al. 2000); the largest number of wild bonytail were collected in the early and mid-1960's upstream of Jensen (Vanicek and Kramer 1969). The bonytail was reported in decline following the period of dam construction throughout the Colorado River Basin in 1905.

Stressor: Predation by nonnative fish species
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: A large number of nonnative fishes are found in historic and currently occupied habitat of bonytail. Many of these are considered predators, competitors, and vectors of parasites and diseases (Tyus et al. 1982; Lentsch et al. 1996; Pacey and Marsh1999). Many researchers believe that nonnative species are a major cause for lack of recruitment in the native fishes, including bonytail (McAda and Wydoski 1980; Minckley 1991; Tyus 1987). There are

numerous reports of predation of native fish eggs and larvae by common carp (Cyprinus carpio), channel catfish (Ictalurus punctatus), smallmouth bass (Micropterus dolomeiui), largemouth bass (Micropterus salmoides), bluegill (Lepomis macrochirus), green sunfish (Lepomis cyanellus), and redear sunfish (Lepomis microlophus; Jonez and Sumner 1954; Langhorst 1989; Marsh and Langhorst 1988). Marsh and Langhorst (1988) found that larval razorback sucker in Lake Mohave grew better in the absence of predators, and Marsh and Brooks (1989) reported that channel catfish and flathead catfish (Pylodictis olivaris) were major predators of newly stocked razorback sucker in the Gila River. Juvenile razorback sucker (average 171 mm TL) stocked in isolated coves along the Colorado River in California suffered extensive predation by channel catfish and largemouth bass (Langhorst 1989). Similar results are reported for bonytail in isolated riverside ponds along the lower Colorado River near Parker, Arizona (personal communication, C. Minckley, U.S. Fish and Wildlife Service). Similar effects of predation on native fishes are reported from the Upper Colorado River Basin. Lentsch et al. (1996) identified six species of nonnative fishes as existing threats, including red shiner (Cyprinella lutrensis), common carp, sand shiner (Notropis stramineus), fathead minnow (Pimephales promelas), channel catfish, and green sunfish. Small forms, such as adult red shiner, are known predators of larval native fish (Ruppert et al. 1993). Large predators, such as walleye (Stizostedion vitreum) and northern pike (Esox lucius) also pose a threat to subadult and adult native fishes (Tyus and Beard 1990).

Stressor: Hybridization
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Intergrades among the Colorado River Gila have been reported by several investigators (Holden and Stalnaker 1970; Valdez and Clemmer 1982; Kaeding et al. 1990; Douglas et al. 1989, 1998). The presence of intergrades in the wild suggests hybridization among bonytail, roundtail chub, and humpback chub; hybridization has been demonstrated under hatchery conditions (Hamman 1981). Some have suggested that hybridization is the result of a breakdown in reproductive isolating mechanisms caused by habitat and streamflow changes in the basin (Valdez and Clemmer 1982), while others (Dowling and DeMarais 1993) hypothesize that introgressive hybridization has played a significant role in generating the great morphological diversity in the genus Gila and providing additional genetic variability. The effect of hybridization on the Gila species is unclear, and the factors that lead to increased hybridization of bonytail are not evaluated, because there are no reproducing populations in the wild. Current levels of hybridization are not considered singly significant in the decline of the bonytail, but these factors will be reevaluated at downlisting and any necessary protection will be implemented at delisting.

Stressor: Pesticides and pollutants
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: The potential role of pesticides and pollutants in suppressing populations of Gila were discussed by Wick et al. (1981). Over 16 percent of young roundtail chub from the Yampa and Colorado rivers in 1981 showed spinal deformities (i.e., lordosis), hypothesized to be related to high pesticide levels from local agricultural applications (Haynes and Muth 1981). Other pollutants in the system include petroleum products, heavy metals (e.g., mercury, lead, zinc, copper), nonmetalics (i.e., selenium), and radionucleides. Although these elements are

concentrated in some regions of the basin, no tissue analyses have been conducted for bonytail to determine current levels of bioaccumulation. Selenium has been identified as a potential problem for razorback sucker and Colorado pikeminnow (Osmundson et al. 2000a). Potential spills of hazardous materials threaten all endangered fishes. The Denver and Rio Grande Western railroad tracks parallel the Colorado River at Black Rocks and upper Westwater Canyon with the risk of derailment and spills of materials into the river, although no known derailments have occurred in these areas. The susceptibility of stocked bonytail to toxic substances is illustrated by a large, but unquantified loss of humpback chub in Westwater Canyon in the 1980's as a result of a large ash flow following a range wildfire high in the watershed (personal communication, J. Cresto, U.S. Bureau of Land Management). The potential for spills of petroleum products also exists for repatriated bonytail in Yampa Canyon. For example, numerous petroleum-product pipelines cross or parallel the Yampa River upstream of Yampa Canyon, most of which lack emergency shut-off valves. One pipe ruptured in the late 1980's releasing refined oil into the Yampa River, but the effects of this spill were not documented. Another cause of degraded water quality is the Atlas Mills tailings pile located on the north bank of the Colorado River near Moab, Utah. There are two significant threats to endangered fish posed by the Atlas Mills tailings pile. The first is from toxic discharges of pollutants, particularly ammonia, through groundwater to the Colorado River. The second is the risk of catastrophic pile failure, that could bury important nursery areas and destroy other fish habitat.

Recovery

Reclassification Criteria:

When, over a 5-year period, genetically and demographically viable, selfsustaining populations are maintained in the Green River subbasin and upper Colorado River subbasin such that (a) the trend in adult (age 4+; greater than or equal to 250 mm total length) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 4,400 adults (4,400 is the estimated minimum viable population [MVP] needed to ensure long-term genetic and demographic viability);

a genetic refuge is maintained in a suitable location (e.g., Lake Mohave, Lake Havasu) in the lower basin recovery unit;

two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (e.g., mainstem and/or tributaries) such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults;

certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Recovery Priority Number: 5C (USFWS, 2024)

Delisting Criteria:

When, over a 3-year period beyond downlisting, genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and upper Colorado River subbasin such that (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 4,400 adults;

a genetic refuge is maintained in the lower basin recovery unit;

two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults;

certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Recovery Actions:

- Reestablish populations with hatchery-produced fish.
- Identify genetic variability of bonytail and maintain a genetic refuge in a suitable location in the lower basin.
- Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.
- Provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion.
- Investigate options for providing appropriate water temperatures in the Gunnison River.
- Minimize entrainment of subadults and adults at diversion/out-take structures.
- Investigate habitat requirements for all life stages and provide those habitats.
- Ensure adequate protection from overutilization.
- Ensure adequate protection from diseases and parasites.
- Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.
- Control problematic nonnative fishes as needed.
- Minimize the risk of increased hybridization among Gila spp.
- Minimize the risk of hazardous-materials spills in critical habitat.
- Remediate water-quality problems.
- Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).
- Current Recovery Priority Number: 5C (USFWS, 2019).
- Recommended future actions: Additional research providing a better understanding of how habitat alternations, diseases and parasites, nonnative fishes, and potential contaminants affect the physical condition, survival, and reproduction of bonytail could further facilitate this species' recovery. Intensive management remains necessary in order to facilitate this species' recovery. Based on our experience managing the other Colorado River fish, the suite of threat management actions identified in the 2002 Bonytail Recovery Goals still

provide managers with reasonable guidance until more species-specific information is identified. Similarly, we have not gathered compelling information to recommend revising the demographic criteria in those goals. Therefore, we do not recommend revising the Bonytail Recovery Plan at this time and will reevaluate the need for revision at the time of the next 5-year review (USFWS, 2019).

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SPECIES ACCOUNT: *Gila intermedia* (Gila chub)

Species Taxonomic and Listing Information

Listing Status: Endangered; 11/2/2005; Southwest Region (R2)

Physical Description

The Gila chub is small-finned, deep-bodied, chubby (chunky), and darkly colored (sometimes lighter on belly; diffuse lateral band(s) are rarely present). Adult males average about 150 millimeters (mm) (6 inches (in)) in total length; females can exceed 200 mm (8 in). Scales are coarse, large, thick, and broadly overlapped, and radiate out from the base. Lateral-line scales usually number greater than 61 and less than 80. There are usually eight (rarely seven or nine) dorsal and anal fin-rays; pelvic fin-rays typically number eight, but sometimes nine.

Taxonomy

Baird and Girard (1854:28) published a description of the Gila chub, as Gila gibbosa, based on the type specimen collected in 1851 from the Santa Cruz River. For nomenclature reasons, the name was changed by Girard to Tigoma intermedia in 1856, working with specimens from the San Pedro River. Despite that and other name changes, the Gila chub has been recognized as a distinct species since the 1850’s, with the exception of a short period in the mid-1900’s when it was placed as a subspecies of Gila robusta (Miller 1945). For the past 30 years, Gila intermedia has been recognized as a full monotypic species, separate from the polytypic species Gila robusta, both currently accepted as valid (Robins 1991, Mayden et al. 1992).

Historical Range

Historically, Gila chub have been recorded in approximately 30 rivers, streams, and spring-fed tributaries throughout the Gila River basin in southwestern New Mexico, central and southeastern Arizona, and northern Sonora, Mexico (Miller and Lowe 1967; Rinne and Minckley 1970; Minckley 1973; Rinne 1976; DeMarais 1986; Bestgen and Propst 1989). Several populations may have originally had basin-wide distributions (e.g., Babocomari River and Santa Cruz River).

Current Range

Small remnant populations of the historical distribution remain in most of the drainages with the exception of the Salt and San Simon Rivers, where all known populations have been extirpated. An observation of a Gila chub in Turkey Creek in the upper Gila River Basin in New Mexico was made in 2001 (Telles, pers. comm., 2001, cited by USFWS 2002). The current known distribution in Mexico has been reduced to two small spring areas, Cienega los Fresnos and Cienega la Cienegita, adjacent to the Arroyo los Fresnos (tributary of the San Pedro River), within 2 km (1.2 mi) of the Arizona-Mexico border (Varela-Romero et al. 1992). No Gila chubs remain in the Mexican portion of the Santa Cruz River basin (Weedman et al. 1996).

Distinct Population Segments Defined

No.

Critical Habitat Designated

Yes; 11/2/2005.

Legal Description

On November 2, 2005, the U.S. Fish and Wildlife Service (Service), listed the Gila chub (Gila intermedia) as endangered with critical habitat under the Endangered Species Act of 1973, as amended (Act). The final rule will implement the Federal protection and recovery provisions of the Act for this species. Approximately 160.3 river miles (mi) (258.1 kilometers (km)) of critical habitat located in Grant County, New Mexico, and Yavapai, Gila, Greenlee, Graham, Cochise, Santa Cruz, Pima, and Pinal Counties in Arizona was designated.

Critical Habitat Designation

The critical habitat for the Gila intermedia includes seven units totaling 160.3 miles of stream reaches in Grant County, New Mexico, and Yavapai, Gila, Greenlee, Graham, Cochise, Pima, Santa Cruz, and Pinal Counties in Arizona. The seven areas designated as critical habitat are: (1) Upper Gila River Area; (2) Middle Gila River Area; (3) Babocomari River Area; (4) Lower San Pedro River Area; (5) Lower Santa Cruz River Area Area; (6) Upper Verde River Area; and (7) Aqua Fria River Area.

Area 1: Upper Gila River Area: This area lies in Grant County, New Mexico, and Greenlee County, Arizona. Critical habitat includes several tributary streams: Turkey Creek, Dix Creek, Harden Cienega Creek, Eagle Creek, and East Eagle Creek. All of these segments are currently occupied by the Gila chub. These tributaries represent the few remaining tributaries of a low desert river that currently provide the necessary habitat for the Gila chub, in a largely natural state. Threats to this critical habitat area requiring special management and protections include fire, grazing, and nonnative species (see Table 1 above). a. Turkey Creek (New Mexico)—22.3 km (13.8 mi) of creek extending from the edge of the Gila Wilderness boundary and continuing upstream into the Gila Wilderness in the Gila National Forest. Turkey Creek contains one or more of the primary constituent elements, including perennial pools and the necessary vegetation that provides cover. Turkey Creek supports a population of Gila chub; surveys confirmed the species presence in 2005 (P. C. Marsh, ASU, in litt. 2005). Land ownership is entirely Gila National Forest and private. b. Eagle Creek and East Eagle Creek— 39.2 km (24.4 mi) of creek extending from the confluence of Eagle Creek with an unnamed tributary upstream to its confluence with East Eagle Creek, and including East Eagle Creek to its headwaters just south of Highway 191. Nine other native fishes known to occupy Eagle Creek include loach minnow (Tiaroga cobitis), spikedace (Meda fulgida), longfin dace (Agozia chrysogaster), speckled dace, Sonora sucker (Catostomus insignis), desert sucker (Catostomus clarkii), razorback sucker, roundtail chub, and an undetermined trout species (Oncorhynchus sp.). This upper portion of Eagle Creek contains one or more of the primary constituent elements, including a series of permanent pools with riffle (shallow area in a streambed causing ripples), run areas between these pools, and the necessary vegetation that provides cover. A diversion dam just below the end of the proposed critical habitat reach acts as a barrier to prevent nonnatives from invading from the Gila River. Periodic flooding appears to decrease the presence of nonnatives, subsequently decreasing the impacts to native fishes by nonnatives in Eagle Creek above this diversion dam (Marsh et al. 1990). East Eagle Creek contains one or more of the primary constituent elements, including a series of permanent pools with riffle, run areas between these pools, and the necessary vegetation that provides cover. East Eagle Creek is also hydrologically connected to Eagle Creek. Gila chub were most recently documented in Eagle Creek in 2005 (Marsh 2005). Land ownership for this segment is predominantly FS, but includes some private land. c. Harden Cienega Creek—22.6 km (14.0 mi) of creek extending from its confluence with the San Francisco River in and continuing upstream to its headwaters. Harden Cienega Creek contains one or more of the primary constituent elements, including perennial pools and the necessary vegetation that provides cover. AGFD surveyed this stream in 2005 and found Gila chub to be abundant (McKell 2005). Land ownership for this segment is Apache-Sitgreaves National Forest, Gila National Forest, and private inholdings. d. Dix Creek—Portions of the Creek beginning 1.0 mile upstream from its confluence with the San Francisco River at a natural rock barrier and continuing upstream for 0.9 km (0.6 mi.) to the confluence of the right and left forks of Dix Creek. This critical habitat area also includes the Left Prong of Dix Creek as it continues upstream 2.0 km (1.2 mi), and the Right Prong of Dix Creek as it continues upstream 4.8 km (3.0 mi). The barrier at the lower end of Dix Creek appears to be effective in isolating the upper drainages from nonnative fish. Dix Creek contains one or more of the primary constituent elements, including perennial pools, and is devoid of nonnatives. AGFD surveyed this stream in 2005 and found Gila chub to be abundant (McKell 2005). Land ownership for these segments is entirely Apache-Sitgreaves National Forest.

Area 2: Middle Gila River Area: This area lies in Graham, Gila, and Pinal counties, Arizona. Critical habitat includes a tributary stream as critical habitat: Mineral Creek. The Mineral Creek population of Gila chub fills a gap of what was previously determined unoccupied habitat within the Middle Gila River Area. This may help to expand future populations of Gila chub in the Middle Gila River Area. Critical habitat within Mineral Creek consists of 14.4 km (8.9 mi) of creek extending from the confluence with Devil's Canyon upstream to its headwaters. Gila chub currently occupy Mineral Creek, and this area contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Below this area, Mineral Creek flows through a mine, where it has been contaminated and does not provide suitable habitat. AGFD documented Gila chub in Mineral Creek in 2000 (Weedman 2000). The area below the mine is not being designated as critical habitat. Land ownership for this segment is Tonto National Forest, Arizona State lands, and private. Threats to this critical habitat area requiring special management and protections include fire, grazing, and nonnative species.

Area 3: Babocomari River Area: This area lies in Santa Cruz County, Arizona. Historically the Babocomari River was a perennial stream which flowed through cienegas and marshlands all the way to the San Pedro River. However, livestock overgrazing destroyed much of the river. In 1995, AGFD found that the only water use was a large impoundment in the river, on the Babocomari Ranch. Perennial flows begin upstream from this impoundment near T–4 Spring. Gila chub were first collected from the Babocomari River in 1892 near Fort Huachuca Military Reservation and again in 1950, approximately 3.5 mi below the Babocomari Ranch (Weedman et al. 1996). Tributaries to this area include O'Donnell Canyon and Turkey Creek, which are designated as critical habitat. Threats to this critical habitat area requiring special management and protections include fire, grazing, and nonnative species (see Table 1 above). a. O'Donnell Canyon—10.0 km (6.2 mi) of creek extending from its confluence with Turkey Creek upstream to the confluences of Western, Middle, and Pauline Canyons. O'Donnell Canyon provides the full range of primary constituent elements necessary for the conservation of the Gila chub. AGFD surveyed O'Donnell Creek and found Gila chub in O'Donnell Creek, although at very low numbers, in 2004 (Dean Foster, AGFD, in litt. 2005). Land ownership is BLM, Coronado National Forest, and private. b. Turkey Creek—6.3 km (3.9 mi) of creek extending from its confluence with O'Donnell Canyon upstream to where Turkey Creek crosses AZ Highway 83. Turkey Creek contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Gila chub have not been detected in Turkey Creek since 1991, although in wet years this segment is connected to occupied habitat in O'Donnell

Creek (Weedman et al. 1996). Land ownership is Coronado National Forest and private lands.

Area 4: Lower San Pedro River Area This area lies in Graham and Cochise counties, Arizona. Gila chub currently exist in several tributaries of this segment of the San Pedro River. Historically, Gila chub most likely occurred on both sides of the lower San Pedro River; however, documentation of Gila chub presence only exists for the east-side drainages. We are only designating critical habitat for the eastside drainage areas. Threats to this critical habitat area requiring special management and protections include fire, grazing, and nonnative species (see Table 1 above). a. Bass Canyon—5.5 km (3.4 mi) of creek extending from its confluence with Hot Springs Canyon upstream to the confluence with Pine Canyon. Perennial water was documented by Dave Gori (TNC, in litt., 1995) for this stream from the confluence with Hot Springs Canyon upstream 4.8 km (3.0 mi). The remainder of the stream was dry for 8 km (5.0 mi). All the State land in the Muleshoe Preserve was traded to the BLM and is managed by TNC. Beginning in 1991, biologists with TNC established eight fixed sample stations in Bass Canyon, five in Hot Springs, and three in Double R Canyon. Beginning in 1992, random pools were also sampled in the streams each year. Gila chub were collected from 1992 to 2003 in Bass Canyon (B. Rogers, TNC, in litt. 2005). Bass Canyon contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Land ownership includes BLM and privately owned lands. b. Hot Springs Canyon—10.5 km (6.5 mi) of creek extending from its confluence with Bass Canyon downstream. The occurrence of Gila chub within this reach of Hot Springs Canyon is sporadic due to the limited number of pools; however, Gila chub are commonly found where good pool habitat exists in Hot Springs Canyon (per. comm. TNC, 2000). Hot Springs Canyon contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Gila chub were found in Hot Springs Canyon in 2004 (B. Rogers, TNC, in litt. 2005). Land ownership includes BLM, State lands, and private. c. Redfield Canyon—9.8 km (6.1 mi) of creek extending from its confluence with Sycamore Canyon downstream. The first documented collection of Gila chub in Redfield Canyon was in 1961. A number of collections of Gila chub occurred from 1976 to 1983, and most recently in 2003. Redfield Canyon contains one of the few populations of Gila chub for which population studies have been conducted (Griffith and Tiersch 1989). Fall Fish Count (FFC) sites were established and surveyed by volunteers from 1988 to 1990. TNC established monitoring stations from 1991 to 1994. Gila chub were collected each year, and they were the most abundant species caught in 1991 (72% of the total fish caught) (Weedman et al. 1996). TNC surveyed Redfield Canyon in November 2001, and Gila chub were documented. This segment of Redfield Canyon is remote and relatively pristine. Additionally, no livestock grazing is permitted, which contributes to the existence of the primary constituent elements for the Gila chub. Redfield Canyon has an abundant and healthy Gila chub population. Redfield Canyon contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Land ownership includes BLM, State lands, and private.

Area 5: Lower Santa Cruz River Area: This area lies in Pima County, Arizona. Tributaries included in the critical habitat designation are Cienega Creek, Mattie Canyon, Empire Gulch, and Sabino Canyon. Threats to this critical habitat area requiring special management and protections include fire, grazing, and nonnative species (see Table 1 above). a. Cienega Creek—There are two segments of critical habitat designated in Cienega Creek. The first segment is in the lower part of the drainage, and includes 14.2 km (8.8 mi) of creek extending from where Cienega Creek becomes Pantano Wash to where it crosses Interstate 10. The second segment is in the upper part of the drainage and extends from its confluence with Empire Gulch on BLM lands to a point 13.6 km (8.4 mi) downstream. Perennial water exists within the lower segment in the Cienega Creek Natural Preserve managed by the Pima County Flood Control District. In June 2005, Gila chub were documented in this lower segment of Cienega Creek. The upper segment of Cienega Creek is considered to be one of the finest natural habitats for the Gila chub, and was the only stream segment with a population of Gila chub considered stable-secure by Weedman et al. (1996). Fish inventories of Cienega Creek and its tributaries, Mattie Canyon and Empire Gulch, have been conducted since 1989 by seining, electrofishing, and visual observation. Composition of native fish in Cienega Creek varies from its upper to lower reaches, as well as from year to year. Fish sampling is difficult in Cienega Creek because of the large volume of vegetation cover, great pool depths, and undercut banks. Visual observation and electrofishing data show that a large population of adult Gila chub occupy the upper perennial segment of Cienega Creek. Visual observations of adult Gila chub made for the aquatic habitat inventory in 1989 and 1990 found 368 chub along the upper perennial length of Cienega Creek. This estimate is undoubtedly low due to water turbidity in some reaches, vegetation cover, and the secretive nature of Gila chub. Cienega Creek contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Gila chub were found in the upper segment of Cienega Creek in 2004 (D. Foster, AGFD, pers. comm. 2005) and in the lower segment in 2005 (D. Duncan, Service, in litt. 2005). Land ownership for the upper segment is BLM. The lower segment is owned by Pima County. b. Mattie Canyon—4.0 km (2.5 mi) of creek extending from its confluence with Cienega Creek upstream to the BLM Boundary. Gila chub were observed in Mattie Canyon in 2005 (J. Simms, BLM in litt. 2005). Mattie Canyon contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Land ownership is BLM. c. Empire Gulch—5.2 km (3.2 mi) of creek extending from its confluence with Cienega Creek continuing upstream through BLM lands. The majority of this reach is on BLM land and contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Gila chub were documented in Empire Gulch in 1995 and in 2001 (67 FR 51948). Land ownership is BLM. d. Sabino Canyon—11.1 km (6.9 mi) of creek extending from the southern boundary of the Coronado National Forest upstream to its confluence with the West Fork of Sabino Canyon. Sabino Canyon is managed by the Coronado National Forest. Sabino Canyon was devastated by the Aspen Fire in July 2003. Gila chub were salvaged during the fire, and later returned in May 2005 (AGFD 2005a). Sabino Canyon contains one or more of the primary constituent elements, including perennial pools and adequate water quality. Land ownership is Coronado National Forest.

Area 6: Upper Verde River Area This area lies in Yavapai County, Arizona. We are designating four tributaries within the Verde River drainage as critical habitat: Walker Creek, Red Tank Draw, Silver Creek, and Williamson Valley Wash. The Upper Verde River is the northwestern most part of the Gila chub’s historical range. Conserving these Gila chub populations will help maintain representation of the species throughout its historical range. All of these segments have at least one of the primary constituent elements present. Threats to this critical habitat area requiring special management and protections include fire, grazing, residential development, water use, and nonnative species (see Table 1 above). a. Walker Creek—7.6 km (4.7 mi) of creek extending from Prescott National Forest Road 618 upstream to its confluence with Spring Creek. The earliest known collection of Gila chub was in 1978 by J. Rinne (Weedman 1996). Walker Creek was surveyed in 1994 by AGFD at five different locations; Gila chub were collected at three of those locations. Gila chub were collected in Walker Creek by Service biologists in 2005 (Service data). The ephemeral nature of the lower end of Walker Creek appears to be limiting the invasion of nonnative species from Wet Beaver Creek (Weedman et al. 1996); the only nonnative species found in 2005 were virile crayfish (Orconectes virilis). Walker Creek contains one or more of the primary constituent elements, including perennial pools and the necessary vegetation that provides cover. Land ownership is Coconino National Forest and private lands. b. Red Tank Draw—11.1 km (6.9 mi) of creek extending from the National Park Service boundary just upstream of its confluence with Wet Beaver Creek upstream to the confluence of Mullican and Rarick canyons. Red Tank Draw is an intermittent stream that offers abundant Gila chub habitat in the form of perennial pools. Gila chub were documented in Red Tank Draw in 1996 by AGFD, and by the Service in 2005. Green sunfish and virile crayfish are present in the downstream reaches of this stream segment. Red Tank Draw contains one or more of the primary constituent elements, including perennial pools and the necessary vegetation that provides cover. Land ownership is Coconino National Forest and private. c. Spring Creek—5.7 km (3.6 mi) of creek including all non-private lands extending from the boundary of Forest Service land and continuing upstream to the Arizona Highway 89A crossing. Gila chub were documented in 2005 in Spring Creek by Service biologists (Service data). Spring Creek contains all of primary constituent elements, with the exception of habitat free from nonnative aquatic species; virile crayfish are the only nonnative present. Four other native fish species occur in Spring Creek: speckled dace, longfin dace, Sonora sucker, and desert sucker. Land ownership is Coconino National Forest and private. d. Williamson Valley Wash—7.2 km (4.4 mi) of creek extending from the gauging station upstream to the crossing of the Williamson Valley Road. In 1990 Williamson Valley Wash was surveyed for Gila chub and collected on the Matli Ranch, and a large stretch of stream had perennial water (Weedman et al. 1996). In July 2001, Williamson Valley Wash was resurveyed, and Gila chub were abundant (Bryan Bagley in litt. 2001), although they appear to have become much more rare since that time (Bill Leibfried, in litt. 2005). Williamson Valley Wash contains the full range of primary constituent elements necessary for the conservation of the Gila chub. Williamson Valley Wash is entirely on private lands.

Area 7: Agua Fria River Area This area lies in Yavapai County, Arizona. There are six tributaries in the Agua Fria River that are designated as critical habitat, all of which are currently occupied by Gila chub: Little Sycamore Creek, Sycamore Creek, Indian Creek, Silver Creek, Lousy Canyon, and Larry Creek. The Agua Fria River Area represents part of the upper northwest area of the historical range of the Gila chub, and current Gila chub populations in the six drainages of this river area are healthy. There have been no reports of any diseases associated with the Gila chub in this area. Survey results indicate a good representation of all age classes. However, the Cave Creek Complex Fire burned over 248,000 acres in summer 2005, threatening Gila chub populations in this area; individual fish were salvaged from Gila chub populations in Sycamore Creek, Indian Creek, and Silver Creek (Knowles et al. 2005). Gila chub were introduced to Larry Creek and Lousy Canyon as a conservation action in July 1995 (Weedman et al. 1996) by the BLM. Conserving these Gila chub populations will help maintain representation of the species throughout its historical range. Threats to this critical habitat area requiring special management and protections include fire, grazing, and nonnative species (see Table 1 above). a. Little Sycamore Creek—4.7 km (2.9 mi) of creek extending from its confluence with Sycamore Creek upstream. This segment is intermittent but always contains some habitat in the form of perennial pools; Gila chub expand into larger habitats when they are available. Little Sycamore Creek contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Gila chub were documented in Little Sycamore Creek in 2003 (A. Silas, FS, pers. comm. 2005). Land ownership is

Prescott National Forest and private. b. Sycamore Creek—18.3 km (11.4 mi) of creek extending from its confluence with Little Sycamore Creek upstream to Nelson Place Spring. Sycamore Creek is perennial throughout most of its length, with the last 3 km (2 mi) being intermittent. Gila chub were documented in Sycamore Creek in 2005 when they were removed as part of a salvage effort to secure the population from the effects of the Cave Creek Complex Fire (Hedwall et al. 2005). In surveys in 2002, there were no nonnatives collected and all age classes were represented. Gila chub distribution was limited to the area between the Double T Waterfall and the Rock Bottom Box totaling a length of 5 km (3.0 mi) of habitat. Both of these sites are effective fish barriers and seem to have served to prevent nonnatives from invading this upper section of Sycamore Creek. Due to the remoteness of this area, it is unlikely that additional threats to the existing Gila chub population will be of concern. Livestock grazing is very limited in the upper portion of this reach due to the canyons and inaccessibility to the stream. However, below the fish barriers, livestock have access to these areas. Sycamore Creek contains one or more of the primary constituent elements, including perennial pools, the necessary vegetation that provides cover, and adequate water quality. Land ownership is Prescott National Forest and private. c. Indian Creek—8.4 km (5.2 mi) of creek extending from Upper Water Springs downstream into BLM lands. Gila chub were first collected in Indian Creek in May 1995. Gila chub were salvaged from Indian Creek in 2005 to secure the population from the Cave Creek Complex Fire (J. Voeltz, AGFD in litt. 2005). Similar to Little Sycamore Creek, this segment is intermittent, but there is always some habitat available in the form of perennial pools; Gila chub expand into larger habitats when they are available. Indian Creek contains one or more of the primary constituent elements, including perennial pools and the necessary vegetation that provides cover (per. comm. BLM 2002). Land ownership is BLM, Prescott National Forest, and private. d. Silver Creek—8.5 km (5.3 mi) of creek extending from a spring on FS lands downstream onto BLM lands, all of which is located above a natural waterfall/barrier located 4 km (2.5 mi) above the confluence with the Agua Fria River. The earliest record of Gila chub collected in Silver Creek was in 1980. Due to high recruitment of young-of-theyear, Silver Creek was the source of Gila chub that were translocated to Larry Creek and Lousy Canyon in July 1995. Gila chub were salvaged from Silver Creek to protect the population from the Cave Creek Complex Fire in 2005 (D. Weedman, AGFD in litt. 2005). Silver Creek contains one or more of the primary constituent elements, including perennial pools and the necessary vegetation that provides cover (per. comm. BLM 2002). Land ownership is Tonto National Forest and BLM. e. Lousy Canyon—Extending from the confluence of an unnamed tributary upstream to the fork with an another unnamed tributary approximately 0.6 km (0.4 mi) upstream. In 1995, BLM introduced Gila chub from Silver Creek into Lousy Canyon. In 2005, the Service surveyed the stream and observed Gila chub. Lousy Creek contains one or more of the primary constituent elements, including perennial pools and the necessary vegetation that provides cover. In addition, this area is within a canyon, and it is inaccessible to cattle due to the geological nature of the canyon, which acts as a barrier. Land ownership is BLM. f. Larry Creek—Portions of the creek from an unnamed tributary upstream 0.7 km (0.4 mi) to the confluence of two adjoining unnamed tributaries. In 1995, BLM introduced Gila chub from Silver Creek into Larry Creek, and the population appears to be thriving (Service files). Larry Creek contains one or more of the primary constituent elements, including perennial pools and the necessary vegetation that provides cover (Service files). In addition, this area is within a canyon, and it is inaccessible to cattle due to the geological nature of the canyon which acts as a barrier. The Service visually surveyed Larry Creek in 2003 and found Gila chub to be abundant. Land ownership is BLM.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the primary constituent elements are the following:

(i) Perennial pools, areas of higher velocity between pool areas, and areas of shallow water among plants or eddies all found in small segments of headwaters, springs, or cienegas of smaller tributaries;

(ii) Water temperatures for spawning ranging from 17 to 24° C (62.6 to 75.2° F), and seasonally appropriate temperatures for all life stages (e.g. varying from approximately 10°C to 30°C);

(iii) Water quality with reduced levels of contaminants, including excessive levels of sediments adverse to Gila chub health, and adequate levels of pH (e.g. ranging from 6.5 to 9.5), dissolved oxygen (e.g. ranging from 3.0 to 10.0) and conductivity (e.g. 100 to 1000 mmhos);

(iv) Food base consisting of invertebrates (e.g., aquatic and terrestrial insects) and aquatic plants (e.g., diatoms and filamentous green algae);

(v) Sufficient cover consisting of downed logs in the water channel, submerged aquatic vegetation, submerged large tree root wads, undercut banks with sufficient overhanging vegetation, large rocks and boulders with overhangs, and a high degree of streambank stability and healthy, intact riparian vegetative community;

(vi) Habitat devoid of nonnative aquatic species detrimental to Gila chub or habitat in which detrimental nonnatives are kept at a level that allows Gila chub to continue to survive and reproduce; and

(vii) Streams that maintain a natural flow pattern including periodic flooding.

Special Management Considerations or Protections

Each stream segment includes a lateral component that consists of 300 feet on either side of the stream channel measured from the stream edge at bank full discharge. This lateral component of critical habitat is intended as a surrogate for the 100-year floodplain.

Lands located within the boundaries of the critical habitat designation, but are excluded by definition include: Existing paved roads; bridges; parking lots; dikes; levees; diversion structures; railroad tracks; railroad trestles; water diversion canals outside of natural stream channels; active gravel pits; cultivated agricultural land; and residential, commercial, and industrial developments. These developed areas do not contain any of the primary constituent elements, do not provide habitat or biological features essential to the conservation of the Gila chub, and generally will not contribute to the species’ recovery. managed. Proper management may include the use of fencing, rest rotation grazing systems, and other improvements to allotments such as new water tanks. With regard to water use, maintaining high quality and adequate quantities of water for all life stages of Gila chub may involve special management actions such as retaining an adequate buffer of riparian vegetation to help filter out sediment and contaminants, and maintaining streamflow via sustainable levels of ground and surface water use.

Special management considerations for each area will depend on the threats to the Gila chub in that critical habitat area. For example, special management that addresses the threat of nonnative species could include efforts to remove nonnative species from a creek, via chemical compounds that kill fish (e.g. rhotenone) but otherwise do not harm the environment, and construction of fish barriers that prevent the upstream movement of nonnative fishes into Gila chub habitat. Special management that addresses the threat of fire could include using prescribed fire to reduce fuel loads and prevent catastrophic wildfires, and salvaging individuals from populations that are threatened by wildfire. Livestock grazing is only a threat to Gila chub if not properly

Life History

Feeding Narrative

Adult: Gila chub are omnivorous (feed on both plant and animal substances)(Griffith and Tiersch 1989). Adults appear to be principally carnivorous, feeding on large and small aquatic and terrestrial invertebrates and sometimes other small fishes (Rinne and Minckley 1991). Smaller individuals often feed on organic debris and aquatic plants (especially filamentous (threadlike) algae, and less intensely on diatoms (unicellular or colonial algae). Griffith and Tiersch (1989) dissected 27 Gila chub stomachs from Refield Canyon, finding aquatic material that included speckled dace and dobsonfly nymphs (order Megaloptera). Terrestrial insects included primarily ants, with some caterpillars and beetles. Diatoms (algae) were most common by volume. Bottom feeding may also occur, as suggested by presence of small gravel particles.

Reproduction Narrative

Adult: In Monkey Spring, a relatively-constant spring-fed pond, reproduction may last throughout late winter, spring, and summer, and perhaps into autumn (Minckley 1969, 1985). In other areas it occurs mostly in late spring and summer (Minckley 1973). Most Gila chub probably mature in their second or third year of life (Griffith and Tiersch 1989). Spawning probably occurs over beds of submerged aquatic vegetation or root wads. Warmer watertemperatures 20 to 24 degrees Celsius (C) (68 to 75.2 degrees Farenheit (F) were found to increase breeding colorintensities (Nelson 1993). In the 2002 Status Survey for the roundtail chub, spawning temperatures ranged from 20°C to 26.5°C (68 to 79.7°F).Thus, warmer water temperatures may contribute to a successful spawn. Bestgen (1985) concluded that temperature was the most significant environmental factor triggering spawning.

Geographic or Habitat Restraints or Barriers

Adult: Dams lacking a suitable fishway; high waterfall; upland habitat.

Environmental Specificity

Adult: Moderate

Tolerance Ranges/Thresholds

Adult: 10 cfs of streamflow; water temperatures, pH, sufficient dissolved oxygen, and conductivity ranging from 10.5 °C to 25.19 °C, 7 to 9.5, 6.22 mg/l to 10.13 mg/l, and 125 mmhos to 438 mmhos, respectively; temperatures for spawning ranging from 20 to 26.5°C (68 to 79.7°F)

Habitat Narrative

Juvenile: Older juveniles use higher-velocity stream areas (Minckley 1973, 1991) than adults. Sub-adults may be more active and visible in the summer and be observed farther from cover and be observed more frequently in shallow areas with measurable current as water temperatures increased (Dudley 1995).

Adult: Gila chub are highly secretive, preferring quiet deeper waters, especially pools, or remaining near cover including terrestrial vegetation, boulders, and fallen logs (Rinne and Minckley 1991). Undercut banks created by overhanging terrestrial vegetation with dense roots growing into pool edges provide ideal cover (Nelson 1993). Gila chub can survive in larger stream habitat such as the San Carlos River, and artificial habitats, like the Buckeye Canal (Stout et al. 1970; Rinne 1976). Gila chub interact with spring and small stream fishes regularly (Meffe 1985), but prefer deeper waters (Minckley 1973). Adults often are found in deep pools and eddies below areas with swift current. Gila chubs may be highly reclusive in winter, occupying dark interstitial space and may be found in deep water with small substrates, but often away from cover (Dudley 1995). Gila chub require the following habitat elements: Deep pools and eddies below areas with swift currents and streams that maintain a natural unregulated flow pattern including periodic natural flooding; water quality with a minimum of 10 cfs of streamflow, water temperatures, pH, sufficient dissolved oxygen, and conductivity ranging from 10.5 °C to 25.19 °C, 7 to 9.5, 6.22 mg/l to 10.13 mg/l, and 125 mmhos to 438 mmhos, respectively; water quality with reduced levels of contaminants or any other water quality characteristics, including excessive levels of sediments, adverse to Gila chub health; food base consisting of invertebrates, filamentous (threadlike) algae, and insects; sufficient cover consisting of downed logs in the water channel, submerged aquatic vegetation, submerged large tree root wads, undercut banks with sufficient overhanging vegetation, large rocks and boulders with overhangs; habitat devoid of nonnative aquatic species detrimental to Gila chub or habitat in which detrimental nonnatives are kept at a level which allows Gila chub to continue to survive and reproduce.

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant

Dispersal

Adult: Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats.

Immigration/Emigration

Adult: Not available.

Dispersal/Migration Narrative

Adult: Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats.

Population Information and Trends

Threats and Stressors

Recovery

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SPECIES ACCOUNT: *Gila nigrescens* (Chihuahua chub)

Species Taxonomic and Listing Information

Listing Status: Threatened; 10/11/1983; Southwest Region (Region 2) (USFWS, 2016)

Physical Description

The Chihuahua chub averages 5-6 inches in length at maturity and may reach 12 inches. The origin of the dorsal fin is behind that of the pelvic fin and the dorsal fin ray count is usually 9. There are usually 67-78 scales in the lateral line. Coloration is dusky brown above and whitish below. During the breeding season an orange-red color develops around the mouth and lower fins, and on more colorful individuals this also occurs on the pelvic and pectoral fins and lower sides of the head and body. Post-larval G. nigrescens are characterized by a spot above the lateral line, immediately preceding the caudal fin. (USFWS, 1986)

Taxonomy

Due to taxonomic revision of the genus Gila, a conflict with homonyms developed, and the present name Gila nigrescens was adopted, with the Rio Janos at Boca Grande, Chihuahua, Mexico, recognized as the type locality. While the name Gila nigrescens has also been applied by various authors (e.g. Jordan 1891; Koster 1957) to the chub that resides in the Rio Grande and Pecos drainages, that species (the Rio Grande chub, Gila pandora) is quite distinct and should not be confused with the true G. nigrescens of the Guzman drainage. (USFWS, 1986)

Current Range

This species is restricted to tributaries of the endorheic Guzman basin, including the Mimbres River (Sublette et al. 1990) in New Mexico and the Guzman and Laguna Bustillos basins in Chihuahua, Mexico (Propst and Stefferud 1994, Page and Burr 2011). (NatureServe, 2015)

Critical Habitat Designated

No;

Life History

Feeding Narrative

Juvenile: Takes insects from water surface; feeds also on small aquatic invertebrates, fish fry, and some plant matter (Matthews and Moseley 1990). (NatureServe, 2015)

Adult: Takes insects from water surface; feeds also on small aquatic invertebrates, fish fry, and some plant matter (Matthews and Moseley 1990). (NatureServe, 2015)

Reproduction Narrative

Adult: The reproductive biology of Chihuahua chub has not been studied; however, observations of reproductive condition have been made during surveys. In lower elevations in Chihuahua, Mexico, reproductively ripe individuals were found in March (Propst and Stefferud 1994) while Sublette et al. (1990) indicate that spawning occurs in late April or May in New Mexico. Based on reproductive condition and size of individuals in various months, Propst (1999) suggests that spawning may extend from early spring through fall. Observations by NMDGF during sampling events suggest spawning occurs into late summer in New Mexico. Eggs are scattered over sand/silt substrates (Sublette et al. 1990). Sublette et al. (1990) suggest that Chihuahua chub is an opportunistic carnivore, feeding on invertebrates and possibly fish. However, no specific studies on food habits have been conducted (USFWS, 2023)

Environmental Specificity

Adult: Moderate (USFWS, 2010)

Habitat Narrative

Juvenile: Juveniles tend to occupy shallower habitats with or without cover. (NatureServe, 2015)

Adult: Adult Chihuahua chub are considered habitat specialists. They are found in their natural habitats primarily in lateral scour pools, beneath undercut banks, or under other solid objects (e.g., logs, boulders) adjacent to moderate to fast flowing water in small to medium sized streams (Miller and Chernoff 1979, Propst and Stefferud 1994). Corner and backwater pools containing large woody debris are also used as habitat. Almost all natural habitats occupied by Chihuahua chub have extensive cover composed of organic debris or root wads of large trees. Pools are typically 1-2 m deep with a water velocity of less than 15 cm/second, and substrates are small-grained (sand to pea-size) (Propst and Stefferud 1994, Propst 1999). Juveniles are found in shallower water with or without cover (USFWS, 2023)

Dispersal/Migration

Motility/Mobility

Adult: High (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Not available.

Population Information and Trends

Population Trends:

Long-term population trends suggest a decline of 50-70% and short-term declines of 10-30% (NatureServe, 2015)

Number of Populations:

8 Extant Populations (USFWS, 2023)

Population Size:

Unknown but likely <10,000 (NatureServe, 2015)

Population Narrative:

Information from Mexico is limited to the trend seen between historical collections and the three surveys that were done in 1964, 1979, and 1990 (Miller and Chernoff 1979, Propst and Stefferud 1994). Primarily because of water extraction, diversion (stream drying), and pollution, there was a downward trend in site occupancy over time in the streams of Chihuahua (Miller and Chernoff 1979, Propst and Stefferud 1994). Miller and Chernoff (1979) found the species at only 8 of 16 sites where it had formerly been common, and it was abundant at only 3 of the 8 sites. Propst and Stefferud (1994) found the range and abundance of Chihuahua chub in Chihuahua, Mexico had decreased dramatically, and that the species was only comparatively common in remote areas relatively free of habitat modification. No additional surveys have been conducted in Mexico since the 1990s. Therefore, for the purposes of this status review we presume the status of the species in Mexico has continued to decline given limited conservation efforts, continued habitat loss, and continued effects of climate change. The Mimbres River, New Mexico was stocked in 2010, 2013, 2015, 2016, and 2018-2021 (Table 1 and Figure 8). Typically, Chihuahua chub 76-100 mm (3-4 in) are stocked on NMDGF and The Nature Conservancy (TNC) properties, but stockings upstream at Monument and Cooney Canyons have also taken place since the last 5-year review. Annual surveys of the Mimbres River are conducted by NMDGF in the fall and have been ongoing since the 1990s (Johnson 2022). Monitoring indicates that expansion of the population took place after the near extirpation of the Mimbres River population because of the Silver Fire in 2013. Prior to the Silver Fire, the population was considered stable (USFWS 2010). The full dynamics of fish movement in the system are not well understood, but movement of fish may explain the fluctuation in catchper-unit-effort during sampling (Figure 1). The habitat on the mainstem of the Mimbres River has supported all age classes (USFWS, 2023).

Threats and Stressors

Stressor: Loss of habitat (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Within the historical range of the Chihuahua chub, stream and wetland habitat have been destroyed or degraded, and loss of this habitat continues today (Miller and Chernoff 1979, Minckley and Deacon 1991, ContrerasBalderas and Lozano-V. 1994, Propst 1999, Edwards et al. 2002, ContrerasBalderas et al. 2008). Activities such as groundwater pumping, surface water diversions, impoundments, dams, channelization, improperly managed livestock grazing, wildfire, agriculture, mining, road building, timber harvest, and residential development all contribute to riparian and cienega habitat loss and degradation in New Mexico and Mexico (Miller and Chernoff 1979, Minckley and Deacon 1991, Contreras-Balderas and Lozano-V. 1994, Propst 1999, Edwards et al. 2002, Contreras-Balderas et al. 2008). The local and regional effects of these activities are expected to increase with increasing human population because a larger human population will result in increased development. Of the activities listed, stream drying has caused the biggest loss of habitat. Miller and Chernoff (1979) and Propst and Stefferud (1994) provide many examples where historically occupied habitat is now dry. Diversion of streams for crop irrigation, dam installation, and groundwater pumping are the primary causes of stream drying. In addition, any activity that degrades or eliminates the preferred habitat of the adults (e.g., deep pools, undercut banks) such as removal of woody debris from rivers, trampling of banks by livestock, channelization, removal of riparian vegetation, or increased sedimentation will reduce or eliminate populations. Water pollution from agricultural and municipal sources and overgrazing by livestock also create unsuitable habitat. As a consequence of these developments, Chihuahua chub are comparatively common only in the remote areas of Chihuahua where habitat modification is less common (Propst and Stefferud 1994). (USFWS, 2010)

Stressor: Fishing (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Although the Chihuahua chub from the Mimbres River may have served as a food source for Native Americans and early settlers (Service 1986), now it is protected by regulation from angling in New Mexico. However, it may still be an important food source for people in Mexico. Propst and Stefferud (1994) found evidence of, or witnessed imaginative techniques for fish capture in Chihuahua. When the researchers returned Chihuahua chub back to the creek after surveys, the children were dismayed, because the charalitos were the most desirable food fish in the stream (Propst and Stefferud 1994). The impact of human consumption in Mexico is unknown; however, it is unlikely that there is active protection of this species. (USFWS, 2010)

Stressor: Non-native fish (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Only two other fish species are known to have historically co-existed with Chihuahua chub in New Mexico; Rio Grande sucker and beautiful shiner (Cyprinella formosa) (Propst and Stefferud 1994). The beautiful shiner has been extirpated from New Mexico (Propst 1999). Chihuahua chub evolved in a fish community where no predatory fish existed and as a result developed no mechanisms to deal with predation from nonnative species. Most likely, Chihuahua chub was the top predator and experienced little or no predation or competition from other species. Introduction of nonnatives is considered a major factor in the decline of all native fish species (Koster 1957, Minckley and Deacon 1991, Miller et al.1989). In the Mimbres River, longfin dace became established in the 1960s (Sublette et al. 1990) and is the most abundant nonnative fish (Burton 1987). Speckled dace is also present (Propst and Paroz 2007). Competition between these two species and Chihuahua chub has not been studied. Rainbow trout (Oncorhynchus mykiss) is also present in the Mimbres River. Rainbow trout abundance has varied over time but has declined recently (Propst and Paroz 2007). Rainbow trout are potential predators of and competitors with Chihuahua chub. Other nonnative fish are uncommon in the Mimbres River (Propst 1999). In Mexico, nonnative fish recorded in the habitat of Chihuahua chub included black bullhead (Ictalurus melas), brown bullhead (I. nebulosus), bluegill (Lepomis macrochirus), carp (Cyprinus carpio), western mosquito fish (Gambusia affinis), bullhead minnow (Pimephales vigilax), rock bass (Ambloplites rupestris), and largemouth bass (Micropterus salmoides) (Propst 1990). In the Bustillos basin, black bullhead, brown bullhead, and bluegill were present in one or two of the six sites sampled. In the Guzman basin, mosquito fish was the most abundant nonnative caught in the Santa Maria drainage and was found at 7 of 12 sites sampled. Black bullhead and carp were present in 2 of 12 sites. In the Santa Clara drainage, carp was found in three of nine sites and mosquitofish in one of nine. In the Casas Grandes drainage, black bullhead was the most commonly encountered nonnative, present at 6 of 17 sites sampled. Carp, bullhead minnow, mosquito fish, rock bass, bluegill, and largemouth bass were present in 3 or fewer of the 17 sites sampled (Propst 1990). Both Miller and Chernoff (1980) and Propst and Stefferud (1994) cite nonnative species as a threat to Chihuahua chub. (USFWS, 2010)

Stressor: Parasites (USFWS, 2010)
Exposure:

Response:
Consequence:
Narrative: Anchor worm (Lernaea cyprinacea) (Copepoda), also a nonnative species, is an external parasite, and infects a wide range of fishes and amphibians. Lernaea infection has killed large numbers of fish due to tissue damage and secondary infection of the attachment site (Hoffnagle and Cole 1997) and was responsible for the loss of 21 Chihuahua chub captured at Moreno spring and transported to DNFHTC for use as brood stock (Burton 1988, Johnson and Jensen 1991). Lernaea infection also was documented from Chihuahua chub caught in Mexico (Propst and Stefferud 1994). The population of Chihuahua chub in Moreno Springs is infected with yellow grub (Clinostomum marginatum). This parasite is a trematode with a complex life history that includes aquatic snails, freshwater fish, and wading birds (usually a heron) (Klaas 1963). The “yellow grub” is the encysted metacercaria that appears as a yellow, oval spot, 3-6 mm long (Klaas 1963). Common locations for the metacercaria are on the caudal, dorsal, and pectoral fins, on the inside surface of the operculum, and in the muscle tissue. Far fewer fish in the river are infected with yellow grub than those in Moreno Springs (Propst and Paroz 2007) and in general it has been found that even large infestations of yellow grub do not affect the condition factor of fish (Klaas 1963, Newman et al. 1976). However, it is unknown if heavy infestations have an effect on reproductive success (i.e., fewer or less fit offspring). The nonnative parasite Ichthyophthirius multifiliis (‘‘ich’’) is a potential threat to Chihuahua chub. Development of ich is favored by high temperatures and physiological stress, which can occur during crowding as a result of drought (Mpoame 1982). This protozoan becomes embedded under the skin and within the gill tissues of infected fish. When the parasite matures, it leaves the fish, causing fluid loss, physiological stress, and sites that are susceptible to infection by other pathogens. In heavily infected fish, respiration is impaired because of damaged gill tissue. Ich was documented on Chihuahua chub collected from Mexico (Propst and Stefferud 1994) and could become a problem in the Mimbres River under deteriorating water quality conditions (intermittency and warm water temperatures during periods of drought). (USFWS, 2010)

Stressor: Fragmentation (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Chihuahua chub populations have become fragmented and isolated in small stream segments from stream diversion, stream drying, dam installation, and pollution. The isolated populations are vulnerable to natural or manmade factors that might further reduce their population size (Fagan et al. 2002, Noss et al. 2005). Random events, such as drought, floods, and wildfire, can decimate populations of Chihuahua chub. In addition, because of the lack of gene flow, small, isolated populations are subject to genetic threats, such as inbreeding depression and genetic drift (Noss et al. 2005). (USFWS, 2010)

Stressor: Wildfire (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Wildfires are a natural disturbance in forested watersheds. However, since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average frequency during the period 1970–1986. The total area burned is more than six and a half times the previous level (Westerling et al. 2006). In addition, the average length of the fire season

during 1987– 2003 was 78 days longer compared to that during 1970–1986 and the average time between fire discovery and control was 29.6 days longer (Westerling et al. 2006). Although prescribed burns are being used in the United States to mimic the historical fire regime and improve watershed conditions on the Gila National Forest, many decades will likely pass before a natural fire cycle is restored. Fires in the Southwest frequently occur during, or just prior to, the summer monsoon season. As a result, fires are often followed by rain that washes ash-laden debris into streams (Rinne 1996, Brown et al. 2001). It is usually the debris flows, rather than the fires themselves, that impact and sometimes devastate fish populations (Rinne 1996, Brown et al. 2001). Indirect effects of fire also include watershed alteration that can change streamflow, water quality, riparian vegetation, and instream sediment loads, all of which can drastically alter habitat for Chihuahua chub. Ash flows affected the Mimbres River in occupied habitat from 1994-1996 (Burton 1994, Propst 1997). Initially it was thought that there was a complete fish kill (Burton 1994); however, a few Chihuahua chub survived (Burton 1994, Propst 1997). It is unknown if fire has affected populations in Chihuahua. (USFWS, 2010)

Stressor: Climate change (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: According to the Intergovernmental Panel on Climate Change (IPCC 2007) "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years (IPCC 2007). It is very likely that over the past 50 years cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007). Data suggest that heat waves are occurring more often over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007). The ancillary effects of increased temperature, such as increased habitat fragmentation (from stream drying), changes in invertebrate prey base (both species composition and availability) (Ries and Perry 1995, Harper and Peckarsky 2006, Bradshaw and Holazpel 2008), increased frequency and intensity of fire (Westerling et al, 2006), additional invasive species (IPCC 2002, Eaton and Scheller 1996), increased susceptibility and mortality from disease (Ficke et al. 2005, Hari et al. 2006), and effects on water quality (e.g., dissolved oxygen, nutrients, pH) (Meisner et al. 1988, Meyer et al. 1999, Ficke et al. 2005) may also have a negative impact on Chihuahua chub. Because water temperature is correlated to air temperature, it is predicted that water temperatures will rise. It is projected that warmer water temperatures will allow warmwater fishes (native and nonnative) to expand their range (Ficke et al. 2005). Given that Chihuahua chub evolved in a fish community with few species, if additional nonnative species were introduced into their habitat, they may likely have a negative effect on Chihuahua chub. (USFWS, 2010)

Recovery

Reclassification Criteria:
Recovery Priority Number: 5 (USFWS, 2023)

Delisting Criteria:

1. Conservation easements or other legal agreements have been obtained on the spring-fed tributary where the fish presently exist. (USFWS, 1986)

2. Two additional secure populations are successfully established within its former range on the Mimbres River. (USFWS, 1986)

Recovery Actions:

- Provide habitat protection on areas where the Chihuahua chub presently exists or where suitable habitat can be reclaimed. (USFWS, 1986)
- Reclaim two habitats where Chihuahua chub can be reintroduced. (USFWS, 1986)
- Reintroduce Chihuahua chub into reclaimed habitats and monitor those populations to determine success of the reintroduction. (USFWS, 1986)
- Secure water rights in the Mimbres River for Chihuahua chub. (USFWS, 2010)
- Create additional suitable habitat through occupied reaches of the Mimbres River. (USFWS, 2010)
- Engage private land owners in the conservation of Chihuahua chub. (USFWS, 2010)
- Conduct systematic surveys of historical Chihuahua chub streams in Chihuahua, Mexico, to determine current status and monitor trends. (USFWS, 2010)
- Conduct a survey of the population genetics of the Mexico and New Mexico populations of Chihuahua chub. (USFWS, 2010)
- If appropriate, introduce fish from Mexico into the broodstock at DNFHTC. (USFWS, 2010)
- If the habitat is suitable and sustainable, introduce Chihuahua chub into additional tributaries of the Mimbres River. (USFWS, 2010)
- Investigate the possibility of introducing Chihuahua chub into stock tanks in the Mimbres basin that have permanent water. (USFWS, 2010)
- Investigate the opportunities for protecting populations in Chihuahua, Mexico. (USFWS, 2010)
- Revise the recovery plan. (USFWS, 2010)
- Investigate the thermal tolerances of Chihuahua chub. (USFWS, 2010)
- Investigate the diet of Chihuahua chub. (USFWS, 2010)
- Investigate the impact of nonnative species on Chihuahua chub. (USFWS, 2010)
- Improve and protect the habitat near Cooney Canyon, New Mexico. (USFWS, 2010)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Recent genetic studies indicate that the captive population at SNARRC is suffering from a lack of genetic diversity. As such, to maintain a stable and healthy refugia population, future conservation efforts should attempt (where feasible and possible) to cycle new broodstock from wild captured fishes into the SNARRC population. Future monitoring efforts should elucidate survivorship, recruitment, and health of the population of fishes located in the NMDGF River Ranch Refugia Pond. Wildfires often have catastrophic effects on the wild, Mimbres River populations. Therefore, ensuring the species success in this refugia is likely key (USFWS, 2023).

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SPECIES ACCOUNT: *Gila purpurea* (Yaqui chub)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; August 31, 1984 (49 FR 34490).

Physical Description

The Yaqui chub is a medium-sized freshwater minnow fish that reaches 15 centimeters (6 inches) in length (NatureServe 2015). They are dark overall and typically lighter below (USFWS 1995). The bodies of breeding males have a bluish sheen, while breeding females are straw-yellow to light brown (USFWS 1995). A triangle-shaped caudal spot is usually present, and lateral bands are scarcely developed or absent (USFWS 1995).

Taxonomy

The Yaqui chub was originally described as Tigoma purpurea, but was reassigned to the genus Gila in 1945. In 1991, the species was separated into two: Gila eremica (desert chub), which includes all populations except the one in San Bernardino Creek; and Gila purpurea, which occurs in San Bernardino Creek (USFWS 1995). Yaqui chub differs from desert chub in having a larger mouth, a smaller distance between the origins of pectoral and pelvic fins, and a more slender caudal peduncle (DeMarais 1991).

Historical Range

The known historic range of Yaqui chub is restricted to San Bernardino Creek, which is in the San Bernardino National Wildlife Refuge in the southeastern Arizona. San Bernardino Creek crosses the U.S.-Mexico border, and the Yaqui chub range extends less than 3 kilometers (km) (1.9 miles [mi.]) into Mexico (Barkalow and Bonar 2015).

Current Range

Yaqui chub continue to inhabit San Bernardino Creek, but populations have been artificially established in the Leslie Canyon National Wildlife Refuge in an effort to protect the species (Maes and Maughan 1998).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/31/1984.

Legal Description

On August 31, 1984 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Gila purpurea (Yaqui chub) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Arizona (49 FR 34490-34497).

The critical habitat designation for Gila purpurea includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Gila purpurea.

Critical Habitat Designation

The critical habitat designation for Gila purpurea includes one CHU in Cochise County, Arizona (49 FR 34490-34497).

(1) Arizona, Cochise County. All aquatic habitats of San Bernardino NWR in S1/2 Sec. 11; Sec. 14; S1/2 and NE1/4 Sec. 15; T24S. R30E.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (49 FR 34490-34497):

(1) Known constituent elements include clean permanent water with deep pools and intermediate areas with riffles, areas of detritus or heavily overgrown cut banks in the Rio Yaqui drainage, and the absence of introduced exotic fishes.

Special Management Considerations or Protections

Section 7(a) of the Act, as amended, requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the Yaqui chub, beautiful shiner and Yaqui catfish, and requires them to ensure that their actions do not result in the destruction or adverse modification of these critical habitats which have been determined by the Secretary. If a “may affect” determination is made, the Federal agency must enter into consultation with the Service. Regulations implementing this interagency cooperation provision are codified at 50 CFR Part 402 and are now under revision (see proposal at 46 FR 29990: June 29, 1983). The only possible activity with Federal involvement that may potentially affect the designated critical habitat is geothermal exploration. This activity is beyond the boundary of the San Bernardino NWR, but could possibly affect underground aquifers supplying surface waters to the critical habitat. Geothermal exploration in the San Bernardino Valley is subject to Federal regulation and licensing by the BLM. It should be emphasized that critical habitat designation may not affect geothermal exploration activities in the vicinity. The designation of critical habitat for these species does not specifically preclude geothermal development in the area. Exploration activities will be allowed to proceed in the vicinity of critical habitat as long as artesian and surface water supplies at San Bernardino NWR are adequately protected. The Act and implementing regulations found at 50 CFR 17.21 and 17.31 set forth a series of general prohibitions and exceptions which apply to all endangered and threatened wildlife. These prohibitions, in part, make it illegal for any person subject to the jurisdiction of the U.S. to take, import or export, ship in interstate commerce in the course of a commercial activity, or sell or offer for sale these species in interstate or foreign commerce. It also would be illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that was illegally taken. Certain exceptions would apply to agents of the Service and State conservation agencies. Regulations codified at 50 CFR 17.22. 17.23, and 17.32 provide for the issuance of permits to carry out otherwise prohibited activities involving endangered and threatened species under certain circumstances. Such permits are available for scientific purposes or to enhance the propagation or survival of the species. In some instances, permits may be issued during a specified period of time to relieve undue economic hardship which would be suffered if such relief were not available. In addition, the two species proposed as threatened, the Yaqui catfish and beautiful shiner, have a special rule which will allow take for educational, scientific, or conservation purposes in accordance with applicable State laws and regulations. Any violation of applicable State law would be a violation of the Endangered Species Act. At present no State laws or regulations are applicable to the Yaqui catfish or beautiful shiner, because neither species is presently found in Arizona. When the reintroduction of these species into Arizona waters occurs, the State will regulate taking in accordance with already existing laws and regulation regarding fishes. This special rule will allow these fishes to be managed as threatened species, thus allowing for more efficient management of the species, and enhancing their conservation.

Life History

Feeding Narrative

Juvenile: See Adult narrative.

Adult: Yaqui chub are opportunistic omnivores that feed on algae, insects, and detritus. They experience resource competition from nonnative fish, including bullhead catfish (Ameiurus spp.), bluegill (Lepomis macrochirus), and black crappie (Pomoxis nigromaculatus) (USFWS 1995).

Reproduction Narrative

Juvenile: See Adult narrative.

Adult: Yaqui chub spawn in deep pools with aquatic vegetation to provide cover (NatureServe 2015). Spawning occurs continuously during warm months, peaking in spring (USFWS 1995). Adults are capable of producing many offspring in a short amount of time; large populations can develop quickly from few adults (USFWS 1995). Under favorable environmental conditions, juvenile Yaqui chub reach breeding age within their first summer of life (USFWS 1995).

Geographic or Habitat Restraints or Barriers

Juvenile: Dams lacking a suitable fishway or a high waterfall (NatureServe 2015).

Adult: Dams lacking a suitable fishway or a high waterfall (NatureServe 2015).

Spatial Arrangements of the Population

Juvenile: Random

Adult: Random

Environmental Specificity

Juvenile: Generalist, although young occupy near-shore zones in water 1 meter (m) (3.3 feet [ft.]) deep or less, often near the lower end of riffles (Maes and Maughan 1998; USFWS 1995).

Adult: Generalist, although adults tend to occupy the lower part of the water column in water greater than 1 m (3.3 ft.) deep (Maes and Maughan 1998; USFWS 1995).

Tolerance Ranges/Thresholds

Juvenile: Moderate

Adult: Moderate

Site Fidelity

Juvenile: High

Adult: High

Habitat Narrative

Juvenile: See Adult narrative.

Adult: Yaqui chub inhabit freshwater rivers and creeks in southeastern Arizona and northern Sonora, Mexico. Adults tend to remain low in the water column and near vegetative cover in deep (deeper than 1 m [3.3 ft.]) pools, undercut banks, scoured areas of ciénegas (marshy springs at the bases of mountains or the edges of grasslands), and other calm waters slower than 0.04 m/sec (0.13 ft./sec) (48 FR 32527; Maes and Maughan 1998; USFWS 1995). Juvenile Yaqui chub tend to occur in near-shore (1 m [3.3 ft.] depth or less) areas of silt substrate, often near the lower end of riffles (Maes and Maughan 1998; USFWS 1995). Both adults and juveniles seek cover during daytime hours, especially in undercut banks and small and large woody debris (USFWS 1995).The dispersal of Yaqui chub is limited by dams lacking suitable fishways and high waterfalls (NatureServe 2015). Their habitat quality is threatened by human and livestock activities, including agriculture, cattle grazing, and mining. The water in Rio San Bernardino has low suspended sediment concentrations (less than 100 mg/L) for most of the year, but the suspended sediment concentrations dramatically increase during monsoon floods (Barkalow and Bonar 2015). Suspended sediment levels in Rio San Bernardino reached lethal levels for Yaqui chub embryo and fry during four floods in 2012 (Barkalow and Bonar 2015).

Dispersal/Migration

Motility/Mobility

Juvenile: Moderate

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Nonmigratory

Adult: Nonmigratory

Dispersal

Juvenile: Low

Adult: Low

Immigration/Emigration

Juvenile: No

Adult: No

Dependency on Other Individuals or Species for Dispersal

Juvenile: No

Adult: No

Dispersal/Migration Narrative

Juvenile: See Adult narrative.

Adult: The range of Yaqui chub is restricted to San Bernardino Creek in the San Bernardino National Wildlife Refuge in southeastern Arizona, and extends less than 3 km (1.9 mi.) into Mexico (Barkalow and Bonar 2015). They are able to move locally around microhabitats in the creek, but the potential for dispersal or long-distance migration is limited by their small range.

Population Information and Trends

Population Trends:

Relatively stable (NatureServe 2015).

Species Trends:

Yaqui chub has responded positively to management by developing large and viable stocks in diverse habitats (USFWS 1995). As a result of various conservation actions, the current extent of occurrence and area of occupancy are equal to or larger than the historical extent and area (NatureServe 2015).

Population Growth Rate:

Stable

Number of Populations:

6 to 20 (NatureServe 2015)

Population Size:

Unknown (NatureServe 2015)

Resistance to Disease:

Low

Population Narrative:

As a result of various conservation actions, the current extent of occurrence and area of occupancy of Yaqui chub are equal to or larger than the historical extent and area. There are between 6 and 20 stable populations of Yaqui chub, although the size of these populations is unknown (NatureServe 2015). Overall, the species has responded positively to management actions, which have developed large and viable stocks in diverse habitats (USFWS 1995).

Threats and Stressors

Stressor: Agriculture and artesian wells
Exposure: Construction of artesian wells and increased farming.

Response: Reduction in surface water in southeastern Arizona.
Consequence: Loss of Yaqui chub habitat via the conversion of San Bernardino Creek into an arroyo.
Narrative: Construction of artesian wells increased the density of farming in southeastern Arizona. The increase in farming caused a dramatic reduction in aquatic habitat and the associated biota in the region. San Bernardino Creek, the primary habitat for Yaqui chub, was transformed from a marshy ciénega in the 1850s to an arroyo, a typically dry creek that flows only during rain events.

Stressor: Livestock grazing
Exposure: Cattle grazing.
Response: Stream channel incision, diversion, and modification and overuse of aquifers.
Consequence: Reduction in quantity and quality of water in streams.
Narrative: Most of the USA-Mexican borderlands—including all of southeastern Arizona and southwestern New Mexico—have been heavily used for cattle grazing. Grazing pressure led to incision of stream channels that drained and desiccated ciénegas; diversion and modification of stream channels themselves; and excessive exploitation of underground aquifers. This has led to a reduction in quantity and quality of natural surface waters.

Stressor: Competition and predation by nonnative species
Exposure: Nonnative competitors and predators.
Response: Reduced food availability and predation.
Consequence: Declining populations of Yaqui chub.
Narrative: Introduction of nonnative species led to a general decline in aquatic communities. Nonnative predators of Yaqui chub include largemouth bass (Micropterus salmoides), bullfrog (Lithobates catesbeianus), and western mosquitofish (Gambusia affinis). Nonnative competitors/predators of Yaqui chub include bullhead catfish (Ameiurus spp.), bluegill (Lepomis macrochirus), and black crappie (Pomoxis nigromaculatus).

Recovery

Reclassification Criteria:
The following must be met within currently occupied habitat for a period of 10 years before consideration of downlisting for Yaqui chub:

Secure and protect San Bernardino Valley aquifers so that all artesian-well and other flows from subsurface sources are perennial. Secure and protect Leslie Creek, Black Draw, and Mimbres River (New Mexico watersheds) to ensure adequate, perennial flow.

Eradicate all nonindigenous fish species and other undesirable organisms, such as bullfrogs, from critical habitat.

Protect critical habitat and other habitats where Yaqui chub occur or are reestablished from human disturbances, including excessive grazing, irrigated agriculture, mining, introductions of nonindigenous species, and water diversion or removal.

Establish and secure self-sustaining populations on San Bernardino and Leslie Canyon National Wildlife Refuge lands.

Establish and secure self-sustaining populations in West Turkey Creek, Arizona, under a formal Conservation Management Plan or other binding agreement, accepted and implemented by the jurisdictions involved.

Delisting Criteria:
The Yaqui chub will be considered for delisting when: 1) Arizona populations of Yaqui chub will be monitored annually to allow and document viable populations supported by the perpetuation of dozens of reproductive cohorts in a total of ≥ 35 distinct (unconnected) suitable wetland metapopulations within a combination of locations that include SBNWR, LCNWR, El Coronado Ranch, Bar-Boot Ranch, Slaughter Ranch, and other suitable sites in the U.S. This number of metapopulations is at least five times greater than what is identified to have occurred historically for the Yaqui chub in Arizona, and should serve to adequately mitigate anticipated threats to the species. 2) Sonora populations of Yaqui chub are secure, reestablished, and self-sustaining (allowing and documenting populations supported by the perpetuation of dozens of reproductive cohorts) in a total of ≥ 5 (unconnected) suitable wetland metapopulations within a combination of locations that include Rancho San Bernardino and other favorable sites. This number of metapopulations is also about five times greater than what was known historically for the Yaqui chub in Sonora, and should serve to adequately mitigate anticipated threats to the species (USFWS, 2018).

Recovery Actions:
- Cooperate on recovery with Mexico by pursuing agreements and developing management plans for the long-term survival of Yaqui chub in Mexico, and developing and implementing cooperative management plans (USFWS 1995).
- Manage existing habitat and populations by determining aquifer recharge zones, capacities, configurations, and characteristics of subsurface flow; protecting watersheds and aquifers; determining amounts of water required to maintain Yaqui chub; revising and continuing implementation of the San Bernardino/Leslie Canyon National Wildlife Refuge Master Plan (including developing a water-use plan for San Bernardino/Leslie Canyon National Wildlife Refuge, developing and implementing genetic monitoring plans and schedules, and developing and implementing a Yaqui chub management plan); developing or enhancing new and existing habitats and monitoring the success of habitat management; and eradicating and securing against reinvasion or new introductions of nonindigenous species (USFWS 1995).
- Determine the biological requirements of Yaqui chub by examining and documenting its life history; determining impacts of intra- and interspecific interactions in habitats occupied by combinations of species; determining habitat requirements and habitat use; determining and delineating the genetic composition of existing populations; and monitoring the health of Yaqui chub populations and occupied habitats (USFWS 1995).
- Protect historic habitats of Yaqui chub in the United States by maintaining the levels and quality of subsurface waters sufficient to sustain springs and flows of artesian wells, thereby protecting surface waters (including applying proper or enhanced land-use practices, excluding development such as mining or irrigated agriculture, and forging agreements to ensure aquifer water quality); working with water users and appropriate agencies and individuals to prevent overuse of water from essential aquifers; obtaining instream flow-water rights for sufficient water to maintain surface flows in watercourses important to recover; and acquiring and protecting (or protecting through conservation agreements,

habitat management plans, or other binding agreements) the essential waters and habitats needed for long-term survival of Yaqui chub (USFWS 1995).
- Assess habitats for reintroduction and reestablishment of Yaqui chub in appropriate habitats in historic ranges, by identifying areas for possible reintroductions; reintroducing, reestablishing, and monitoring populations of Yaqui chub; and working with public agencies and private landowners to manage existing and reintroduced populations of Yaqui chub (USFWS 1995).
- Develop information and education programs for Yaqui chub, their habitat, and the ecosystem on which they depend, by developing comprehensive programs of information and education; ensuring broad dissemination of information in both English and Spanish; and establishing and maintaining archives of published and unpublished materials relevant to aquatic organisms and aquatic habitats of concern in permanent depositories (USFWS 1995).
- Recommend downlisting to Threatened. Reclassification (from Endangered to Threatened) Priority Number: 5 (USFWS, 2019).
- RECOMMENDATIONS FOR FUTURE ACTIONS: The foremost recommendation for action is that we update our knowledge of Yaqui chub population status in the Rio Yaqui, Mexico, where no new data have been collected since 1994 (Rio Bavispe area; Abarca et al. 1995) and no system-wide surveys have been conducted since those of Hendrickson et al. (1981) (USFWS, 2019).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The foremost recommendation is to determine how pumping for construction of border security infra-structure has impacted the long-term sustainability of the aquifer that supports the wetland ponds that Yaqui chub inhabit. Revised management may require an extensive analysis of the aquifer, development of infra-structure to install pumps, and reconfiguration of wetland ponds to ensure that Yaqui chub continue to be supported on San Bernardino NWR. In addition, we need to update our knowledge of Yaqui chub population status in the Rio Yaqui, Mexico, where no new data have been collected since 1994 (Rio Bavispe area; Abarca et al. 1995) and no system-wide surveys have been conducted since those of Hendrickson et al. (1981). The Yaqui chub has a geographic range that includes very little of Sonora, Mexico (only the headwaters within a few miles of the international border). Yaqui chub populations should be monitored to evaluate response to border construction and associated water withdrawal. When possible, given workloads, a Species Status Assessment should be conducted to guide the development of a recovery plan revision. We recommend that a separate recovery plan be written for the Yaqui chub and that the species not be included in a bundled plan. A new plan should provide up-to-date information on populations of this small desert cyprinid (USFWS, 2020)

Additional Threshold Information:

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SPECIES ACCOUNT: *Gila robusta jordani* (Pahranagat roundtail chub)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Endangered; October 13, 1970.

Physical Description

Roundtail chub are streamlined fish, similar to trout in appearance, and characterized by a robust body and tail. Pahranagat roundtail chubs are olive-gray in color with silvery sides and a white belly. Breeding males develop red or orange coloration on the lower half of the cheek and at the bases of paired fins. Individuals may reach a total length of 49 centimeters (cm) (19.3 inches [in.]) but typically average 24.8 to 30 cm (9.8 to 11.8 in.) (USFWS, 2014).

Taxonomy

Pahranagat roundtail chub are taxonomically aligned with the roundtail chub (Gila robusta) complex of the Colorado River drainage. The Pahranagat roundtail chub was originally granted specific recognition; later authors, however, recognized its similarity to other roundtail chub and redefined it as a subspecies. It was determined through recently conducted research that the Pahranagat roundtail chub is a distinct subspecies. Pahranagat roundtail chub are most similar to roundtail chub in the Colorado River and its larger tributaries, but have more scales in, above, and below the lateral line; are less elongated; and are greenish in color with black blotches (USFWS, 1998).

Historical Range

The Pahranagat roundtail chub historically was found throughout the Colorado River basin from Wyoming to Arizona and into Mexico in the main stem and most large tributaries (USFWS, 2014). The amount of historically occupied habitat is estimated to have totaled approximately 30 kilometers (km) (18.4 miles [mi.]) of stream, including the three springs and their outflows, the Pahranagat Ditch, and Maynard Lake at the southern end of the valley (USFWS, 1998).

Current Range

The Pahranagat Roundtail chub is common to rare in the main stem of the Colorado River and its larger tributaries in the upper Colorado River basin (USFWS, 2014). Currently, this fish is restricted to approximately 3.5 km (2.2 mi.) of the Pahranagat Creek, and 2.5 km (1.6 mi.) of irrigation ditches (USFWS, 1998).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Pahranagat roundtail chubs are slow growers; they may feed more selectively with warmer water temperatures, and prefer to make more efficient use of their energy by eating bigger prey items. During winter, retrieval of smaller prey items in cooler water requires the expenditure of less metabolic energy. Pahranagat roundtail chub forage primarily on drifting invertebrates, and secondarily—though infrequently—by pecking at substrate. The biggest competitors of the Pahranagat roundtail chub are invasive species found in the same areas (USFWS 1998).

Reproduction Narrative

Adult: During breeding season (January and February), when the female is ready to spawn (after reaching maturity at 2 to 3 years of age) she swims down to the gravel bottom, where she is attended by a group of two to 10 males. The spawning group vibrates violently for 3 to 6 seconds, and 2,000 eggs are laid. The female generally swims away and is pursued by males until ready to spawn again. It is believed that females only appear on the spawning site when prepared to spawn, which occurs intermittently over several days. Spawning occurs in relatively fast water in gravel-covered pool bottoms at water depths ranging from 0.58 to 1.04 meters (m) (1.9 to 3.4 feet [ft.]), and water velocity ranging from 0.08 to 0.54 meters per second (m/s) (0.25 to 1.2 feet per second [ft./s]). Water temperatures during the spawning months range from 17.0 to 24.5 degrees Celsius (°C) (63 to 76 degrees Fahrenheit [°F]), and dissolved oxygen concentrations from 5.2 to 6.3 milligrams per liter (parts per million). Pahranagat roundtail chub eggs are broadcast over gravel substrates. Larvae reach "swim-up" stage approximately 28 days after eggs are deposited in the gravel bed. It takes 28 to 53 days for all larvae to leave the spawning beds, with peak emigration occurring on the 30th day. Larval emigration generally occurs between 6:00 p.m. and midnight, with the majority of emigration occurring between 7:00 and 8:00 p.m. Pahranagat roundtail chubs can live up to 7 years (USFWS 1998).

Geographic or Habitat Restraints or Barriers

Adult: Habitat destruction can limit access to river and streams (USFWS 1998).

Spatial Arrangements of the Population

Adult: Clumped according to resources (USFWS 1998).

Environmental Specificity

Adult: Community with key requirements common.

Tolerance Ranges/Thresholds

Adult: Low/moderate

Site Fidelity

Adult: High

Habitat Narrative

Adult: Pahranagat roundtail chub are found in cool to warm fresh water over a wide range of elevations in rivers and streams throughout the Colorado River basin, which can be limited by habitat destruction. Adult Pahranagat roundtail chubs often occupy areas of the deepest pools (depths ranging from 0.4 to 1.4 m [1.3 to 4.6 ft.]), and eddies of mid-sized to larger streams and are often associated with areas of cover in the form of boulders, overhanging cliffs, undercut banks, or vegetation. Adults have also been found in fast-moving water (water velocities up to

0.8 m/s [2.6 ft./s]). However, adult Pahranagat roundtail chub occupy deeper and slower moving water in summer than in spring or winter. This shift is partially attributable to reduced summer water flow and a behavioral response to increased metabolic demands associated with warmer water. Summer water temperatures (29.2 to 32.2°C [85 to 90°F]) are stressful for fish, and potentially lethal. Pahranagat Roundtail chub also reduce their active metabolism and may move into slower water during the summer to reduce energy expenditures. Larval Pahranagat Roundtail chubs occur near the water surface, and along the creek's edge in still water (USFWS 1998)

Dispersal/Migration

Motility/Mobility

Adult: High

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: High

Immigration/Emigration

Adult: Emigration, larvae only: it takes 28 to 53 days after eggs are deposited for all larvae to leave the spawning beds, with peak emigration occurring on the 30th day. Larval emigration generally occurs between 6:00 p.m. and midnight, with the majority of emigration occurring between 7:00 and 8:00 p.m. (USFWS 1998).

Dependency on Other Individuals or Species for Dispersal

Adult: None

Dispersal/Migration Narrative

Adult: The information on Pahranagat roundtail chub migration and dispersal is still being researched. It is known that Pahranagat roundtail chub is mobile, nonmigratory, and, disperses from spawning grounds; however, it is unknown how far they disperse. Larvae emigrate from spawning beds at 28 to 53 days after eggs are deposited, with peak emigration on day 30 (USFWS 1998).

Population Information and Trends

Population Trends:

Decreasing

Species Trends:

Decreasing

Population Growth Rate:

Fluctuates

Population Size:

~100 Adults in Annual surveys (USFWS, 2022)

Resistance to Disease:

Not resistant to disease or infection introduced by nonnative fish.

Adaptability:

Moderate/low

Population Narrative:

The Pahranagat roundtail chub population fluctuates, but the population is in decline. Little is known about the current Pahranagat roundtail chub population size or how it will adapt to changing environments, because it is thought that the species has a low resiliency rate, representation rate, and redundancy rate. The introduction of nonnative fish has also added to the population declines, because Pahranagat roundtail chub are not resistant to diseases introduced (USFWS 1998). Population surveys have been infrequent, and methods have been inconsistent. Since the early 1980s, snorkel surveys have been used to quantify abundance in Pahranagat Creek. Hardy (1982) estimated that there were only 37 to 45 adults remaining. The National Fisheries Research Center – Reno Field Station conducted seasonal surveys between 1986 and 1989 with adult observations totaling between 129 and 252, depending on year and season (Tuttle et al. 1990). A later survey by this group in 1998, now called the U.S. Geological Survey – Western Field Station, documented 162 chub, while a 2001 survey resulted in an alarmingly low number of 15 adult chub observations (McShane et al. 2004). The Nevada Department of Wildlife (NDOW) conducts snorkel surveys on an annual basis to enumerate chub, these surveys typically result in less than 100 observations of individuals (Figure 4; NDOW 2021). The ability of snorkel surveys to reliably assess the abundance of the population remains in question. Recent surveys have varied greatly, with some surveys resulting in encounters as low as two individuals. Variability in counts can likely be attributed to the complexity of habitat, turbidity of water, and behavior of chub. The Pahranagat Creek is a complex habitat with an abundance of down woody debris as well as deep undercut banks, which chub may use for cover and to evade surveyors. The turbidity of Pahranagat Creek varies depending on irrigation practices, there are times when visibility during snorkel surveys is less than five feet due to agricultural runoff from fields. Activity level of chub can vary seasonally and daily, making it difficult for snorkelers to encounter individuals (USFWS, 2022).

Threats and Stressors

Stressor: Habitat loss and degradation related to dams, diversions, groundwater pumping, mining, development, recreation, and livestock grazing.
Exposure: Direct; lower water levels affect Pahranagat roundtail chub. Indirect; loss of riverine canopy.
Response:
Consequence: Reduction in population numbers.
Narrative: The Pahranagat Valley river ecosystem, where the Pahranagat roundtail chub is found, has provided water for irrigation purposes to the surrounding agricultural communities for well over a century. Loss of water and alteration of the stream channel and adjacent habitat have both been a factor in the decline of Pahranagat roundtail chub and its habitat. Areas in Pahranagat Valley have been disturbed by algae removal, water level fluctuation, and recreational activities. These areas are more likely to be predominated by nonnative fishes,

whereas native fish are more common in areas with few or no disturbances. Pahranagat roundtail chub habitat has also had loss of riverine canopy, and has suffered degradation of the riparian habitat due to grazing and crop production; these are believed to be contributing to the declining Pahranagat roundtail chub population. Water levels have fallen or been diverted due to dams and groundwater pumping, which limits the habitat for Pahranagat roundtail chub because it limits the amount of habitat that has year-round water (USFWS 1998).

Stressor: Presence of nonnative aquatic species.
Exposure: Direct; nonnative aquatic species hunt on Pahranagat roundtail chub at all life stages and infect them with diseases. Indirect; nonnative aquatic species out-compete Pahranagat roundtail chub for resources.
Response: Illness, more vulnerable to predation, death.
Consequence: Reduction in population numbers, reduction in resources, decreased reproductive success.
Narrative: Competition and predation by nonnative, introduced aquatic species such as common carp (Cyprinus carpio), convict cichlids, mollies, bullfrogs, crayfish, and the Melanoides sp. snail represent threats to the Pahranagat roundtail chub (USFWS 2008). Only a few fish species occupy the Pahranagat roundtail chub's desert water habitat, so nonnative fish species have been able to establish themselves easily, with deleterious results to native fish communities. The potential outcomes of the invasion of nonnative species include a reduction in native populations, a rapid and apparent niche segregation of other native fish, and the possible extinction of the Pahranagat roundtail chub. Nonnative fish affect the Pahranagat roundtail chub directly by predation and by out-competing the Pahranagat roundtail chub for food and resources. In addition, nonnative fish have introduced fish parasites, including tapeworms, nematodes, and anchor worms into desert-water ecosystems, which have negatively affected the native fish populations. Parasite infestations cause tissue damage, blood loss, and exposure of fish to secondary infections. Heavy infestations may cause reduced longevity, reduced fecundity, and even direct mortality (USFWS 1998).

Stressor: Predation (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Interactions between nonnative species and Pahranagat roundtail chub have not been studied in depth. However, there is potential for predation by nonnative fish species on Pahranagat roundtail chub. The most likely mechanism for this would be predation occurring from overlap between nonnative fish and early life stages (i.e., egg, larval fish) of Pahranagat roundtail chub. Previous work in Nevada by Scoppettone (1993) found that shortfin molly (Poecilia mexicana) were effective larval predators in laboratory settings. Convict cichlid (Amatitlania nigrofasciata) have also been documented on spawning areas, which may be associated with egg predation (USFWS, 2022).

Recovery

Reclassification Criteria:
Pahranagat Creek/Ditch contains adequate cool water pools, for chub to persist through the summer months.

A self-sustaining Pahranagat roundtail chub population (comprising three or more age-classes, a stable or increasing population size, and documented reproduction and recruitment) is present in a combined total of approximately 75 percent of either 6.8 km (4.7 mi.) of the Crystal Spring outflow stream through its confluence during the winter months with the Ash Springs outflow stream, or 10 km (6.2 mi.) of Pahranagat Creek/Ditch below the confluence for three complete generations (or a minimum of 15 consecutive years).

Impacts to the species and its habitat have been reduced or modified to a point where they no longer represent a threat of extinction or irreversible population decline (USFWS 1998).

None

None

Recovery Priority Number: 3 (USFWS, 2022)

Delisting Criteria:
The Pahranagat roundtail chub may be considered for delisting, provided that all reclassification criteria have been met.

A minimum year-round in-stream flow of 1.75 cubic feet per second is present, at the point where Pahranagat Ditch starts, to sustain a Pahranagat roundtail chub population;

The riparian corridor along the outflow stream of Crystal Spring has been enhanced;

All impacts to its habitat have been reduced or modified sufficiently for both the species and land uses to coexist.

A Pahranagat Roundtail chub population as defined in the downlisting criteria inhabits both approximately 75 percent of the 6.8 km (4.7 mi.) of the Crystal Spring outflow stream through its confluence during the winter months with the Ash Springs outflow stream, and approximately 75 percent of the 10 km (6.2 mi.) of Pahranagat Creek/Ditch from the beginning of Crystal and Ash Springs outflows to Upper Pahranagat Lake.

Recovery Actions:
- Maintain and enhance aquatic and riparian habitats in Pahranagat Valley.
- Develop and implement monitoring plans.
- Provide public information and education.
- Establish and maintain populations at Dexter National Fish Hatchery, Key Pittman Wildlife Management Area, and Pahranagat National Wildlife Refuge (USFWS 1998).
- Coordinate with upstream water users to stabilize the flow regime in river/ditch.
- Control nonnative plant and animal species.
- Modify livestock grazing practices.

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS Over the next 5 years, the Service recommends the following: • Establish and maintain secondary populations of Pahranagat roundtail chub. These

efforts should focus on repairing or creating habitat on Federal and State lands (i.e., Key Pittman Wildlife Management Area, Pahranagat National Wildlife Refuge). • Establish local watershed group that focuses on finding win-win situations between water users and management agencies. The water and environmental issues in Pahranagat Valley are complex and providing a forum to exchange ideas and to create better decision-making processes is needed. • Look into feasibility of exchanging water from Ash Spring and Crystal Springs during the summer months to lower stream temperature. • Look into feasibility of retiring water rights or changing the point of diversion to areas to increase flow in Pahranagat Creek. • Implement a rear and release program to increase and/or subsidize the population in Pahranagat Creek. This could also be used to maximize gene diversity in refuge populations. • Evaluate existing population survey protocols and redesign to make more effective at tracking abundance (USFWS, 2022).

Additional Threshold Information:

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SPECIES ACCOUNT: *Gila seminuda (=robusta)* (Virgin River Chub)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/24/1989; Mountain-Prairie Region (Region 6) (USFWS, 2015)

Physical Description

The Virgin River chub is a silvery, medium-sized minnow that averages about 20cm or 8 inches in total length but can grow to a length of 45 cm (18 in). The Virgin River chub can be distinguished from subspecies of G. robusta by the number of rays (9 to 10) in the dorsal, anal, and pelvic fins, and the number of gill rakers (24 to 31). The back, breast, and part of the belly have small, deeply embedded scales that are difficult to see and may be absent in some individuals, hence the name seniinuda. (USFWS, 1994)

Taxonomy

Gila seminuda formerly was included as one named and one unnamed subspecies of Gila robusta. DeMarais et al. (1992) raised seminuda (including the Muddy [Moapa] River population) to species status, an action that has been accepted by the American Fisheries Society (Nelson et al. 2004) and USFWS. The origin of G. seminuda may have included hybridization between G. elegans and G. robusta (DeMarais et al. 1992, Gerber et al. 2001). (NatureServe, 2015)

Historical Range

Virgin River chubs historically were collected within the Moapa River in Nevada and within the inainstein Virgin River from Pah Teinpe Springs (also called La Verkin Springs), Utah, downstream to the confluence with the Colorado River in Nevada (Cope and Yarrow 1875, Cross 1975) (Figure 1). It is likely that Virgin River chubs historically occurred well above Pah Teinpe Springs. (USFWS, 1994)

Current Range

Virgin River chub currently occur in the mainstem Virgin River downstream of La Verkin Springs to the confluence of Beaver Dam Wash. Small numbers of the species occur sporadically downstream of Beaver Dam Wash (Figure 2). In the Muddy River, Virgin River chub are found in an approximately 30.0 km (18.6 mi) reach between Warm Springs Bridge and Wells Siding Diversion (USFWS, 2020)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 1/26/2000.

Legal Description

On January 26, 2000 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Gila seminuda (Virgin River chub) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Arizona, Nevada and Utah (65 FR 4140-4156).

The critical habitat designation for Gila seminuda includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Gila seminuda.

Critical Habitat Designation

The critical habitat designation for Gila seminuda includes one CHU in Washington County, Utah; Mohave County, Arizona; and Clark County, Nevada (65 FR 4140-4156).

Utah, Washington County; Arizona, Mohave County; Nevada, Clark County - The Virgin River and its 100-year floodplain from its confluence with La Verkin Creek, Utah in T.41S., R.13W., sec.23 (Salt Lake Base and Meridian) to Halfway Wash, Nevada T.15S., R.69E., sec.6 (Salt Lake Base and Meridian).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Gila seminuda critical habitat consists of seven components (65 FR 4140-4156):

(1) Water—A sufficient quantity and quality of water (i.e., temperature, dissolved oxygen, contaminants, nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is identified for the particular life stage for each species. This includes the following: 1. Water quality characterized by natural seasonally variable temperature, turbidity, and conductivity;

(2) hydrologic regime characterized by the duration, magnitude, and frequency of flow events capable of forming and maintaining channel and instream habitat necessary for particular life stages at certain times of the year; and

(3) flood events inundating the floodplain necessary to provide the organic matter that provides or supports the nutrient and food sources for the listed fishes.

(4) Physical Habitat—Areas of the Virgin River that are inhabited or potentially habitable by a particular life stage for each species, for use in spawning, nursing, feeding, and rearing, or corridors between such areas: 1. River channels, side channels, secondary channels, backwaters, and springs, and other areas which provide access to these habitats;

(5) 2. areas with slow to moderate velocities, within deep runs or pools, with predominately sand substrates, particularly habitats which contain boulders or other instream cover.

(6) Biological Environment—Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although considered normal components of this environment, are out of balance due to nonnative fish species in many areas. Fourteen introduced species, including red shiner (Cyprinella lutrensis), black bullhead (Ameiurus melas), channel catfish (Ictalurus punctatus), and largemouth bass (Micropterus salmoides), compete

with or prey upon the listed fishes. Of these, the red shiner is the most numerous and has been the most problematic for the listed fishes. Red shiners compete for food and available habitats and are known to prey on the eggs and early life stages of the listed fishes. Components of this constituent element include the following: 1. Seasonally flooded areas that contribute to the biological productivity of the river system by producing allochthonous (humus, silt, organic detritus, colloidal matter, and plants and animals produced outside the river and brought into the river) organic matter which provides and supports much of the food base of the listed fishes; and

(7) 2. few or no predatory or competitive nonnative species in occupied Virgin River fishes' habitats or potential reestablishment sites.

Life History

Feeding Narrative

Juvenile: Fed mainly on debris and chironomids in February, cladophora and debris in June, debris, spirogrya, and cladophora in September, and unidentified drift animals, dragonfly larvae, debris, and cladophora in December; young fed almost exclusively on macroinvertebrates whereas adults (>110 mm TL) fed almost entirely on algae and debris (Greger and Deacon 1988). Cross (1978) found that the diet was up to 90% algae. (NatureServe, 2015)

Adult: Fed mainly on debris and chironomids in February, cladophora and debris in June, debris, spirogyra, and cladophora in September, and unidentified drift animals, dragonfly larvae, debris, and cladophora in December; young fed almost exclusively on macroinvertebrates whereas adults (>110 mm TL) fed almost entirely on algae and debris (Greger and Deacon 1988). Cross (1978) found that the diet was up to 90% algae. (NatureServe, 2015)

Reproduction Narrative

Adult: Spawns late spring to early summer. Eggs hatch in 4-7 days at 19 C. (NatureServe, 2015)

Habitat Narrative

Adult: Habitat includes rocky runs, rapids, pools, and undercut banks of headwaters, creeks, and small rivers (USFWS 1994, Page and Burr 2011). It is most common in deeper areas where waters are swift but not turbulent, and generally it is associated with boulders, root snags, or other cover (USFWS 1994). (NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: High (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Little information presently exists on movement of the Virgin River chub. Downstream movement within the river by adults and other life stages has been noted (Virgin River Fishes Data Base, unpub. data), but the extent of upstream movement is not known. (USFWS, 1994)

Population Information and Trends

Population Trends:

Long-term trends indicate declines of 10 to 90%, whereas short-term trends suggest a decline of 10 to 30% (NatureServe, 2015)

Population Growth Rate:

Steadily declining (NatureServe, 2015)

Number of Populations:

2 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

Long-term population trends indicate declines of 10 to 90%, whereas short-term trends suggest a decline of 10 to 30%. Total adult population size is unknown but presumably is at least several thousand. This species is represented by what can be regarded as two major occurrences (subpopulations), one in the Virgin River and the other in the Muddy River. (NatureServe, 2015)

Threats and Stressors

Stressor: Water diversions (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: In the upper Virgin River, the Hurricane and LaVerkin Ditch Diversions constructed in the late 1890s and early 1900s diverted Virgin River flows a short distance upstream of Pah Tempe Springs in LaVerkin, Utah. These diversions routinely dewatered the river downstream to Pah Tempe Springs under low flow conditions. Those structures remained in service until replaced by the Quail Creek Diversion in 1985. The Quail Creek pipeline capacity is approximately 125 cfs. These historical diversions and the current Quail Creek facilities had the capacity to periodically dry dam the Virgin River; however, current operations maintain a minimum flow of 3 cfs (Lentsch et al. 1995). Water use in the upper river has not changed appreciably since the Quail Lake Project was completed in 1985. The entire flow of the river has been diverted near the present site of the Washington Fields Diversion periodically since the early 1900s through authorized water rights. The Virgin River Program is currently developing a flow recommendation for the river downstream of Washington Fields Diversion in conjunction with operations of a recently constructed fish screen at the head of the irrigation canal (USFWS 2005b). Currently, a minimum flow of 5 cfs passes the Washington Fields Diversion through the operation of the fish screen. Irrigation returns restore a portion of the flow downstream of the diversion structure. (USFWS, 2008)

Stressor: Water quality (USFWS, 2008)
Exposure:
Response:

Consequence:
Narrative: In addition to the obvious loss of habitat associated with diminished flow are effects associated with decreased turbidity and elevated summer temperatures. The effects of unnaturally low levels of turbidity are not completely understood, but appear to cause fish to crowd into habitats with cover, increasing competition for resources and predation. Researchers have shown that Virgin River fish experience physiological limitations and subsequent mortality at approximately 31°C (88°F) (Rehm et al. 2006). Deacon et al. (1987) observed the loss of equilibrium in Virgin River fishes when exposed to 31°C (88°F) and above, which he referred to as the critical thermal maxima Critical thermal maximum differ by species and acclimation conditions. Less well characterized but perhaps of equal concern is a temperature at which behavior is affected; a behavioral thermal maximum. Field observations in the Virgin River indicate that at temperatures in excess of 28°C (82°F) native fish shift their behavior to seek out thermal refuge (deeper pools, groundwater inflows, etc) (Fridell and Morvilius 2005a, Morvilius-Auer and Fridell 2006). The temperature in the above Washington Fields Diversion reach, particularly from Quail Creek Reservoir upstream to Pah Tempe Springs, can be very high during the summer (peak daily temperature above 35°C (95°F), mean daily temperature greater than 29°C (84°F)) (Addley et al. 2005). Similarly, in the lower river, Golden and Holden (2004) report that critical thermal maximum is often exceeded at the Riverside area and can even be exceeded near Beaver Dam Wash where there are large influxes of groundwater. (USFWS, 2008)

Stressor: Sediment release (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: Another factor limiting native fish population in the upper river was the periodic release of sediment that had accumulated behind the Quail Creek Diversion dam (sediment sluicing). Depending on the age of the accumulated sediments, the associated biological oxygen demand and / or sediment oxygen demand could be very high. In the autumn 2003, a sluicing event resulted in depressed dissolved oxygen levels and a subsequent fish kill in the upper river. The Washington County Water Conservancy District recognized that, depending on the circumstances, sluicing could be a threat to the recovery of the Virgin River fish and quickly contracted with a private consultant to develop a sediment management plan (BIO / WEST 2004). That plan, which is based on a model that tracks the amount of sediment accumulating behind the dam (based on U.S. Geological Survey sediment transport data) predicts the quantity of natural stream flow necessary to safely sluice; basically the greater the accumulation of sediment the greater natural stream flow required to safely transport it downstream. In 2005, the USFWS consulted with the U.S. Army Corps of Engineers on the implementation of that plan as a condition of the Washington County Water Conservancy District Quail Creek permit (USFWS 2005c). Proper implementation of the management plan coupled with a standardized monitoring protocol (fish and water quality) has proven to greatly reduce the threat associated with sediment sluicing. (USFWS, 2008)

Stressor: Introduced plants (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: Tamarisk was introduced into the United States from central Asia in the 1830s to stabilize river banks, as a windbreak and as an ornamental plant. This nonnative has taken over

the riparian zone / floodplain of the Virgin River system, especially in low gradient areas with sandy substrates. The tree is tolerant of drought, heat, cold, salinity, fire and flooding. Its roots extend deeper than many riparian plants, thus it can out compete other plants and grow in areas where water is not readily available. The tree can sprout from roots or from branches. Tamarisk occurrences in the Virgin River drainage range from vast monotypic stands to individual trees interspersed within native vegetation, and also as isolated trees and stands in upland areas, where springs or moist soil conditions may be present. Tamarisk can dominate floodplain vegetation and can influence normal river function. Stream channels become restricted and flood flows may cut new channels due to the thick growth or because of tamarisk debris dams. The tree (particularly when in monoculture) impacts native fish habitat and is less desirable for other wildlife such as mammals and birds including the endangered southwestern willow flycatcher (Empidonax trailii extimus). Tamarisk control efforts have begun throughout the Virgin River system. To date, the impetus behind tamarisk control efforts has been to reduce potential fire fuels near wild land / urban interfaces. Large scale tamarisk treatment projects coupled with native revegetation efforts have occurred near the City of Mesquite and downstream toward Halfway Wash by the Bureau of Land Management and National Park Service. Efforts have mainly focused on the higher, less saturated terraces of the floodplain where tamarisk has a stronghold. In treatment areas near the active river channel, a river side fringe (30 feet wide) of tamarisk and native vegetation has been left untouched to minimize effects to the aquatic environment, including the Virgin River fish. Important nesting areas for the southwestern willow flycatcher in the lower river have not yet been treated. (USFWS, 2008)

Stressor: Population growth (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: Population growth in the riverside communities of St. George, Utah, and Mesquite, Nevada, has outpaced national averages for decades. At current growth rates, water demand projections for the City of St. George suggest available resources will be depleted by the year 2020. A proposed 160-mile pipeline from Lake Powell to Washington County, Utah, could supply as much as 70,000 acre feet of water annually for municipal and industrial use in the upper Virgin River drainage. At the time of this review, the Lake Powell pipeline project has entered a preliminary design phase. Based on the level of congressional support, this project has a high likelihood of occurring. Potential effects to the Virgin River fish associated with a trans-drainage diversion and the inter-related population growth include: increased urban runoff; more infrastructure (increased encroachment on river and floodplain for transportation and utility conveyance); more recreational activity in the floodplain; potential introduction of non-native species. However, with this project comes some potential to assist in the recovery of endangered fish by trading out current consumptive uses of Virgin River surface flows with the imported water. It is too early to tell how much room for recovery actions there is in this project. (USFWS, 2008)

Stressor: Non-native fish (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: Introduction and establishment of nonnative fish in western rivers of the USA is a major threat to conservation of native fish assemblages (Minckley and Deacon 1968, Stanford

and Ward 1986, Moyle et al. 1986, Carlson and Muth 1989, Minckley and Deacon 1991, Olden et al. 2006). As recognized in the Recovery Plan, the introduction of nonnative fish species, in particular the red shiner has had detrimental impacts on native fish populations in the Virgin River system. Note: Predation of juvenile or adult fish also are likely a factor, especially when the fish are in limited thermal refuges concentrated in with centrarchids and catfish. This is probably most problematic in the lower river where there are smaller pools and any cover is dominated by predatory nonnative fish. Negative interactions between native species and small bodied nonnatives (red shiner, sand shiner (Notropis straminues), and fathead minnow (Pimephales promelas)) have been documented throughout the Colorado River basin (Haines and Tyus 1990, Rupert et al. 1993, Propst and Gido 2004). Other nonnative species (black bullhead, channel catfish, largemouth bass, bluegill, green sunfish, common carp, mosquitofish, and blue tilapia) pose additional threats to Virgin River fish recovery in the lower river (Albrecht et al. 2007). Golden and Holden (2002) showed the potential for some of these species to impact upper river populations as well. The expansion and increased abundance of blue tilapia in the Muddy River system was implicated in the decline of Virgin River chub population from 1995 to 1998 in that system (Scoppettone et al. 1998). The Bureau of Land Management working with a coalition of resource managers (Nevada Division of Wildlife and others) recently constructed a nonnative fish barrier in the Muddy River system to protect remaining native fish populations and to assist in future recovery actions. Continued efforts to control red shiner will likely reduce the effect of these other nonnative species as well. (USFWS, 2008)

Stressor: Climate change (USFWS, 2008)
Exposure:
Response:
Consequence:
Narrative: According to the Intergovernmental Panel on Climate Change (IPCC) (2007, p. 1) “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.” Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1,300 years (IPCC 2007). It is very likely that over the past 50 years: cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007). It is likely that: heat waves have become more frequent over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007). In the preceding sections we have discussed the effects of diminished stream flows, particularly during the base flow period, and the resulting elevated temperatures to the endangered Virgin River fishes. Throughout designated critical habitat critical thermal maximum and behavioral thermal maximum for woundfin have been and continue to be exceeded for varying periods of time in most years. We can only assume that the predicted changes documented in the IPCC reports will exacerbate already highly stressful conditions during drier years. Still, considerable uncertainty remains concerning the accuracy of these global models to localized areas. It is unlikely climate change will have any effect on nonnative fish invasions. (USFWS, 2008)

Recovery

Reclassification Criteria:

1. Virgin River flows essential to the survival of all life stages of the species are ensured. This will include: development and implementation of operational criteria for existing dams, reservoirs, and diversions that provide for flows sufficient to sustain all life stages near historic levels of abundance; acquisition of priority water rights to ensure instream flows of sufficient water quality and quantity from Pah Tempe Springs downstream to Lake Mead to ensure the species' survival; and agreements to ensure passage, timing, and magnitude of flows necessary for channel maintenance during appropriate periods of the year. (USFWS, 2008)

2. Degraded Virgin River habitats from Pah Tempe Springs to Lake Mead are improved and maintained to allow continued existence of all life stages at viable population levels. (USFWS, 2008)

3. Barriers to upstream movements of introduced fishes are established, and red shiners and other nonnative species that present a major threat to the continued existence of the native fish community are eliminated upstream of those barriers. (USFWS, 2008)

Delisting Criteria:
1. Two additional self-sustaining populations are established in the wild within its historical range. This will require that adequate protection of available habitat and instream flows are maintained, the populations have been self-sustaining for a minimum of 10 consecutive years, and a plan for genetic exchange between the populations has been developed and implemented. Quantitative criteria and timeframes for defining self-sustaining in more detail will be determined as more information becomes available. (USFWS, 2008)

2. Essential habitats, important migration routes, required stream flow, and water quality of both the Virgin River habitat and the habitat of transplanted populations are legally protected, and the threats of other significant physical, chemical, or biological modification such that the habitat would become unsuitable for the woundfin are removed. (USFWS, 2008)

Recovery Actions:
- Monitor existing populations. (USFWS, 1994)
- Eliminate red shiners from the Virgin River system from Johnson Diversion to Lake Mead. (USFWS, 1994)
- Develop a viable operating protocol for regulated flows within the Virgin River affected by the Quail Creek Reservoir System and other proposed systems. (USFWS, 1994)
- Conduct research on life history. (USFWS, 1994)
- Conduct research on the potential for habitat improvements within the Virgin River. (USFWS, 1994)
- AMENDED RECOVERY CRITERIA Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the ESA are no longer necessary and a listed species may be delisted. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants. Downlisting is the reclassification of a species from endangered to threatened. The term "endangered species" means any species (species, subspecies, or distinct population segment) that is in danger of extinction throughout all or a significant portion of its range. The term "threatened species" means any species that is likely to become an endangered species within the foreseeable

future throughout all or a significant portion of its range. The recovery criterion presented below represent our best assessment of the conditions that would most likely result in a determination that delisting of Virgin River chub is warranted as the outcome of a formal five-factor analysis in a subsequent regulatory rulemaking. Achieving the prescribed recovery criteria is an indication that the species is no longer threatened or endangered, but this must be confirmed by a thorough analysis of the five listing factors. All downlisting criteria from the previous plan were reviewed and found to be adequate. The downlisting criteria address the need for the persistence of resilient, redundant, and representative subpopulations across the range, as well as reducing threats and increasing regulatory certainty. Below, we provide recovery criteria for Virgin River chub that were not included in the 1995 Recovery Plan. Virgin River chub will be considered for delisting when all of the downlisting criteria have been met, in addition to the following recovery criteria: 1. A Conservation Agreement (CA) has been developed and implemented for Virgin River chub that addresses all five listing factors in the Virgin River basin. The CA will help maintain instream flows in the Virgin River while also addressing the ancillary effects of higher water temperatures and reduced habitat availability. The CA will also address efforts to reduce or remove non-native fish, such as red shiner and maintain genetic diversity between the upper and lower basin. The CA will keep the species relevant in decision making, provide regulatory certainty, and will keep the species from being relisted under the Act. 2. A self-sustaining population of adult Virgin River chub with a lambda (rate of growth) greater than or equal to 1 is achieved and maintained within each of the upper and lower Virgin River Basin (sub-populations) for five out of seven years as determined by a population viability analysis. In this context, a self-sustaining population is described as a population that results in sufficient recruitment of naturally produced Virgin River chub into the adult population at levels necessary to maintain a wild adult population in the absence of artificial population augmentation (USFWS, 2018).

- USFWS should conduct a status review or candidate assessment of the Virgin River chub population in the Muddy River, in Nevada. (USFWS, 2008)
- If, the Virgin River chub population in the Muddy River, Nevada, is listed as threatened or endangered the Recovery Plan should be revised to address specific recovery actions and down- and delisting criteria for that population. (USFWS, 2008)
- Upstream of Washington Fields Diversion to Pah Tempe Springs, base flows must be augmented to provide the flows and temperatures needed to assist in the recovery of the woundfin and Virgin River chub. (USFWS, 2008)
- In the short term, provide flows below the Washington Fields Diversion in a quantity that assists in the recovery of the Virgin River fish. In the long term, provide flows in a quantity that assist in recovery of the Virgin River fish throughout critical habitat. (USFWS, 2008)
- Continue to coordinate with State and Local governments in the development and implementation of floodplain and erosion zone ordinances throughout the Virgin River drainage. (USFWS, 2008)
- Complete construction of a proposed nonnative fish barrier in the Virgin River Gorge in Arizona by the fall of 2008; extend Virgin River Program red shiner eradication. (USFWS, 2008)
- Implement an effective nonnative control strategy downstream of the Virgin Gorge Barrier by autumn 2009. (USFWS, 2008)
- Complete construction of a proposed nonnative fish barrier in the lower Virgin River in Nevada by spring 2010. (USFWS, 2008)

- Prior to the next 5-year review, the USFWS should coordinate with State wildlife management agencies to develop a strategy to prevent further invasions of nonnative aquatic species (fish and mollusks) throughout the Virgin River drainage. (USFWS, 2008)
- Implement the proposed VRHCRP within 18 months of the signing of this 5-year review. A coordinated and consistently funded recovery effort in the lower river, as budgets allow, is required to compliment the activities of the Virgin River Program in the upper river. (USFWS, 2008)
- Work with stakeholders in Arizona to partner with the Virgin River Program, and with the VRHCRP when established, to fully incorporate occupied, and federally designated Critical Habitats into coordinated recovery actions. (USFWS, 2008)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The continued persistence of woundfin and Virgin River chub will require the active management of populations and habitat conditions for the foreseeable future. The VRP has successfully led the implementation of conservation and recovery measures in the upper Virgin River Basin. The VRP provides a vehicle for adaptive broad-based collaborative management between local, state, and Federal interests and resource agencies. The persistence and recovery of woundfin and Virgin River chub is contingent on maintaining communication and cooperation between these interests. Secure funding for the VRP and its signatory partners is imperative to continue recovery actions in the current range of woundfin and Virgin River chub. A similar collaborative management effort needs to extend downstream through the lower Virgin River in Arizona and Nevada. Human population growth and associated development has escalated in the Virgin River Basin in the last 25 years. The area has rapid population growth and increasing demands on the Virgin River system for water use. Providing instream flows to address high water temperatures and maintain adequate habitat and management of nonnative fishes is critical for the recovery of woundfin and Virgin River chub. Adaptive management is necessary to monitor Virgin River fish status, rapidly implement conservation actions, evaluate population response to those actions, and respond proactively to exploit recovery opportunities. Based on the current status of woundfin and Virgin River chub, the primary recommendations for recovery include protecting and enhancing woundfin and Virgin River chub populations within their current distribution, and expanding the range of woundfin and Virgin River chub to ensure redundancy and resiliency. Actions to protect and enhance current woundfin and Virgin River chub populations continue to be implemented through the VRP. Basinwide recovery priorities for woundfin and Virgin River chub are identified and evaluated annually by the Recovery Team. Recovery actions are then implemented by the VRP and lower basin partners. Progress on those actions are reviewed annually and modified as necessary. The recovery of woundfin and Virgin River chub requires expanding populations and increasing occupied geographic range. Establishing viable populations in the Virgin River downstream of the WFD increases population resiliency and significantly decreases vulnerability. Woundfin and Virgin River chub populations remain vulnerable to both stochastic and catastrophic events within their current limited geographic distribution. Eradication of red shiner and establishing populations downstream of the WFD remains the highest priority for recovery of both species. Although significant progress has been achieved since 2000, it is imperative to continue downstream red shiner eradication to facilitate recovery of woundfin and Virgin River chub. Following red shiner eradication, a fish barrier on the lower Virgin River is critical to prevent recolonization of the Virgin River by red shiner and other nonnative fish from Lake Mead. In addition, establishing a stable, reproducing woundfin population upstream of the QCD would increase distribution and significantly enhance its ability to withstand drought periods and episodic water quality events. The Virgin River mainstem above the QCD has largely natural flow conditions with protected base flows, unregulated high flow events, sediment transport, and channel forming/habitat maintenance flows. Although, it is unknown whether woundfin will persist in the Virgin River upstream of the QCD, water temperatures during summer baseflow periods are less extreme and are likely to support woundfin survival and recruitment. It may also provide an upstream source capable of supplementing the woundfin population between Ash Creek and WFD. Finally, a stable reproducing woundfin population upstream of the QCD would increase distribution and significantly enhance woundfin populations within their current range. A viable upstream population would achieve redundancy and resiliency by significantly enhancing the species ability to withstand drought periods, episodic water quality events, and other stochastic and catastrophic events. To ensure redundancy and resiliency, woundfin and Virgin River chub populations need to be reestablished throughout the Virgin River from Johnson Diversion downstream into Arizona and Nevada. First, the downstream eradication of red shiner will need to continue. This will require ongoing cooperation between Recovery Team partners in the upper and lower Virgin River. To ensure eradication success, permanent fish barriers need to be constructed to prevent red shiner recolonization. Once this is accomplished, native fish will need to be reestablished in the lower Virgin River. To facilitate recovery, additional factors limiting recruitment and survival of native fish populations will need to be evaluated and addressed on a reach by reach basis (e.g., nonnative fish, instream temperature and flow, water quality). Conservation actions to remove limiting factors and establish viable populations of woundfin and Virgin River chub must then be implemented (e.g., control smallmouth bass and red shiner, mitigate high instream temperatures, increase instream flows, protect riparian habitat). In addition, we recommend evaluating the status of the Muddy River population of Virgin River chub and, if warranted, including the population into a revised recovery strategy and criteria. Recommendations to address population resiliency, redundancy, and representation are summarized below for woundfin (Table 4) and Virgin River chub (Table 5). (USFWS, 2020)

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SPECIES ACCOUNT: *Hybognathus amarus* (Rio Grande silvery minnow)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 07/20/1994, 12/08/2008; Southwest Region (R2) (USFWS, 2016)

Physical Description

Silvery minnows are a stout fish, with a small, subterminal mouth, with long pharyngeal dentition with a distinct grinding surface and a pointed snout that projects beyond the upper lip (Sublette et al. 1990). The back and upper sides of silvery minnow are silvery to olive, the broad middorsal stripe is greenish, and the lower sides and abdomen are silver. The fins are moderate in length and variable in shape, with the dorsal and pectoral fins rounded at the tips. The body is fully scaled, with breast scales slightly embedded and smaller. The scales about the lateral line are sometimes outlined by melanophores, suggesting a grid pattern. The eye is small and orbit diameter is much less than gape width or snout length (Bestgen and Propst 1996). Maximum total length attained in New Mexico specimens is about 3.5 inches (90 mm) (Sublette et al. 1990). The only readily apparent sexual dimorphism is the expanded body cavity of ripe females prior to spawning (Bestgen and Propst 1994); however, there are some notable differences. The pectoral fins of males flare broadly from their base to a triangular fan shape, while those of females are shorter, narrower, and oval shaped. The pectoral rays of breeding males are thickened, while those of females are slender, and the pectoral fin length in males is also significantly greater.

Taxonomy

In the past, the silvery minnow was included with other species in the genus Hybognathus due to morphological similarities, including a distinct, convex jaw. Phenetic and phylogenetic analyses corroborate the hypothesis that Hybognathus amarus is a distinct valid taxon, and separate from other species of Hybognathus (Cook et al. 1992; Bestgen and Propst 1994), particularly the placement of its subterminal mouth. It is now recognized as one of seven species in the genus Hybognathus in the United States and was formerly one of the most widespread and abundant minnow species in the Rio Grande basin of New Mexico, Texas, and Mexico (Pflieger 1980; Bestgen and Platania 1991). Currently, Hybognathus amarus is the only remaining endemic, pelagic-spawning minnow in the Middle Rio Grande. The speckled chub (Macrhybopsis aestivalis), Rio Grande shiner (Notropis jemezanus), phantom shiner (Notropis orca), and bluntnose shiner (Notropis simus simus) are either extinct or have been extirpated from the Rio Grande (Bestgen and Platania 1991).

Current Range

The silvery minnow currently occupies a 170-mile reach of the Rio Grande, from Cochiti Dam in Sandoval County, to the headwaters of Elephant Butte Reservoir in Socorro County (Service 2010). This includes a small section of the lower Jemez River, a tributary to the Rio Grande north of Albuquerque. The silvery minnow's current habitat is limited to approximately seven percent of its former range, and is split into four discrete reaches by three river-wide dams. Historically, the silvery minnow likely occurred in 3,967 km (2,465 mi) of rivers in New Mexico and Texas and was one of the most abundant and widespread species in the Rio Grande Basin (Bestgen and Platania 1991). The species was known to have occurred upstream to Española, New Mexico (upstream from Cochiti Lake); in the downstream portions of the Rio Chama and

Jemez River; throughout the Middle and Lower Rio Grande to the Gulf of America; and in portions of the Pecos River from Sumner Reservoir downstream to the confluence with the Rio Grande (Sublette et al. 1990; Bestgen and Platania 1991). The current distribution of the silvery minnow is limited to the Rio Grande between Cochiti Dam and Elephant Butte Reservoir, which amounts to approximately 7 percent of its historical range. In December 2008, 2009, and 2010, silvery minnows were introduced into the Rio Grande near Big Bend, Texas, as a nonessential, experimental population under section 10(j) of the ESA (73 FR 74357, USFWS 2008a). The success of these efforts is evaluated through monitoring of the silvery minnows reintroduced into that portion of the Rio Grande and is ongoing. In 2010, the Service found evidence of successful reproduction with the detection of silvery minnow eggs, larval and juvenile fish. In 2011, silvery minnows had distributed 70 miles further downstream and 15 miles upstream of their distribution in 2010. Success of the Big Bend 10(j) population will continue to be evaluated and relevant information incorporated into the assessment for potential reintroductions in additional locations. The Rio Grande, prior to widespread human influence, was a wide, perennially flowing, aggrading river characterized by a shifting sand substrate (Biella and Chapman 1977). The river freely migrated across a wide floodplain and was limited only by valley terraces and bedrock outcroppings. Throughout much of its historic range, the decline of the silvery minnow can be attributed in part to destruction and modification of its habitat due to dewatering and diversion of water, water impoundment, and modification of the river (channelization). The construction of mainstem dams, such as Cochiti Dam and several irrigation diversion dams, have contributed to the decline of the silvery minnow (USFWS 2010a). Cochiti Dam was constructed on the main stem of the Rio Grande in 1973 for flood control and sediment retention (Julien et al. 2005). The construction of Cochiti Dam affected the silvery minnow by reducing the magnitude and frequency of peak flow events and floods that help to create and maintain habitat for the species (Dudley and Platania 1997; Julien et al. 2005). In addition, the construction of Cochiti Dam has resulted in degradation of silvery minnow habitat within the Cochiti Reach downstream of the Cochiti Dam. Water released through Cochiti Dam is now generally clear, cool, and free of sediment. Below Cochiti Dam, there is relatively little channel braiding, and areas with reduced velocity and sand or silt substrates are now uncommon (Julien et al. 2005). Cochiti Dam also created a barrier for movement upstream by silvery minnows (USFWS 2010a). As recently as 1963, silvery minnows were collected upstream of Cochiti, New Mexico; however surveys since 1983 suggest that silvery minnows are now extirpated from in or above Cochiti Reservoir (USFWS 2010a). Substrate immediately downstream of Cochiti Dam is often composed of gravel and cobble (rounded rock fragments generally 8 to 30 cm [3 to 12 in] in diameter). Farther downstream, the riverbed is gravel with some sand and silt substrate. Tributaries including Galisteo Creek and Tonque Arroyo introduce sand and silt during stormwater runoff to the lower sections of the Cochiti Reach, and some of this sediment is transported further downstream along with flows (Salazar 1998; USFWS 1999, 2001). Long-term monitoring of silvery minnows in the Middle Rio Grande began in 1993 and has continued annually, with the exception of 1998 (Dudley et al. 2012a). The long-term monitoring of silvery minnows has recorded dramatic annual fluctuations in density, measured in October, over time (Figure 3). For example, silvery minnow catch rates declined two to three orders of magnitude between 1993 and 2003, but then increased three to four orders of magnitude by 2005 and continue to fluctuate (Figure 3). Catch rate data suggest that the population of silvery minnows declined through early 2000, increased by 2005, and during 2010 and 2011, were below their levels at the time of their listing as an endangered species in 1994. The recent capture of zero wild silvery minnows during October 2012 population monitoring indicated that silvery minnow populations are not stable and have declined precipitously

(Dudley et al. 2012). Catch of silvery minnow, in October, was positively correlated with the magnitude and duration of the spring runoff (Dudley and Platania 2008b). However, errors associated silvery minnow catch and distribution appears to complicate direct comparisons of catch rates (Goodman 2012). Augmentation with hatchery-reared silvery minnows has likely sustained the silvery minnow population throughout its range over the last decade (Remshardt 2008b). Nearly 1,750,000 silvery minnows have been released since 2002. Hatchery-propagated and released fish supplement the native adult population, most likely prevented extinction during the extremely low water years of 2002, 2003, and 2012, and allowed for quicker and more robust population response in all reaches due to improved water conditions observed in recent years (USFWS 2010a). Since 2008, augmentation has only occurred in the Isleta and San Acacia Reaches in order to monitor the success of previous stocking efforts in the Angostura Reach (USFWS 2011a). Dudley et al (2012a) reported the catch rate of silvery minnows from 0 per 100 m2 in the San Acacia Reach, whereas, average catch rate was 0.03 per 100 m2 in September 2012. Population monitoring efforts from February 1993 to September 2011, had an average density of silvery minnows in the San Acacia Reach of 15.9 (±82.2) per 100 m2 and ranging from 0 to 1,742 per 100 m2 (without considering silvery minnow density in isolated pools, n=1,217). Approximately 144,000 hatchery-reared silvery minnows were released at sites in the San Acacia Reach during November 2012 (T. Archdeacon, Service, 26 November 2012, written communication). However, the low number of wild silvery minnow collected during September 2012 and their absence in October 2012 confirms that there was very poor survival and recruitment following spawning earlier in 2012 (Dudley et al. 2012a). Middle Rio Grande Distribution Patterns During the early 1990s, the catch rates of silvery minnows generally increased from upstream (Angostura Reach) to downstream (San Acacia Reach). During surveys in 1999, over 98 percent of the silvery minnows captured were downstream of SADD (Dudley and Platania 2002). This distributional pattern can be attributed to downstream drift of eggs and larvae and the inability of adults to repopulate upstream reaches because of diversion dams. For this reason, an absence of continuous flow in the San Acacia Reach would likely have a disproportionately greater negative effect on silvery minnows when there is a large portion of the silvery minnow population affected by drying events. The San Acacia Reach is often the first of the four reaches of the Middle Rio Grande to experience drying (Platania and Dudley 2003). This pattern shifted in several recent years. In 2004, 2005, and 2007, catch rates were highest in the Angostura Reach and lower in the Isleta and San Acacia Reaches. Routine augmentation of silvery minnows in the Angostura Reach (the focus of augmentation efforts started in 2001) may partially explain this pattern. Transplanting of silvery minnows (approximately 802,700 through 2009) rescued from drying reaches has also occurred since 2003. It is not possible to quantify the effects of those rescue efforts on the silvery minnow population distribution patterns (Remshardt 2010b). Good recruitment conditions (high and sustained spring runoff) throughout the Middle Rio Grande during April and May followed by wide-scale drying in the Isleta and San Acacia Reaches from June to September may also explain the shift. High spring runoff greater than 86 m3/s (3,000 cubic feet per second [cfs]) for 7 to10 days and perennial flow tends to lead to increased nursery habitat and survivorship. In recent times, portions of the Rio Grande south of the Isleta and San Acacia Diversion Dams have had large stretches of river (0.8 to 93.5 miles, average 34.7 miles (USBR 2012) routinely dewatered. Silvery minnows in these areas were subjected to poor recruitment conditions (lack of nursery habitats during low flows) or were trapped in drying pools where many perished (USFWS 2010a). Reports for 2008 indicated high recruitment, at all 20 sampling sites along the Middle Rio Grande, and strong runoff over an extended duration from May to July lead to elevated numbers of this species. Sampling in October 2009, indicated high recruitment, at 19 of the 20 sampling sites. The highest densities were noted to persist in the San Acacia Reach during the population monitoring in October of 2008, 2009, 2010, and 2011. The lack of extensive river drying in 2008 and 2009, and favorable spring peak flows, was likely an important factor in this distribution shift from highest densities in the Angostura Reach in 2007 to the San Acacia Reach in 2008 and 2009 (Dudley and Platania 2008a, 2008b, 2009). During 2010, the silvery minnow was the most common fish species caught in the San Acacia Reach and the least common in the Angostura Reach during monitoring (Dudley and Platania 2010). In late 2010, the Isleta and San Acacia Reaches were stocked with hatchery-raised silvery minnows, and this activity was apparently the primary cause for increased silvery minnow catch rates in those reaches (Dudley and Platania 2011). Even though densities of silvery minnows have shown a tendency to track hydrological patterns, site occupancy data has determined that there has been about a 2% decline since 2005 in the number of occupied sampling units (Dudley et al. 2011a,b,c). This reduced site occupancy has indicated a cumulative loss of about 10% occupied sites in 5 years (Dudley et al. 2011a,b,c).

Critical Habitat Designated

Yes; 2/19/2003.

Legal Description

On February 19, 2003, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Hybognathus amarus (Rio Grande silvery minnow) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes five critical habitat units (CHUs) in New Mexico (68 FR 8088-8135).

The critical habitat designation for Hybognathus amarus includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Hybognathus amarus.

Critical Habitat Designation

The critical habitat designation for Hybognathus amarus includes five CHUs in Socorro, Valencia, Bernalillo, and Sandoval Counties, New Mexico (68 FR 8088-8135).

Unit 1—Jemez Canyon Reach—1 mi (1.6 km) of the Jemez River immediately downstream of Jemez Canyon Dam to the upstream boundary Santa Ana Pueblo

Unit 2—Cochiti Diversion Dam to Angostura Diversion Dam (Cochiti Reach)—21 mi (34 km) of river immediately downstream of Cochiti Reservoir to the Angostura Diversion Dam

Unit 3—Angostura Diversion Dam to Isleta Diversion Dam (Angostura Reach)—38 mi (61 km) of river immediately downstream of the Angostura Diversion Dam to the Isleta Diversion Dam

Unit 4— Isleta Diversion Dam to San Acacia Diversion Dam (Isleta Reach)— 56 mi (90 km) of river immediately downstream of the Isleta Diversion Dam to the San Acacia Diversion Dam

Unit 5— San Acacia Diversion Dam to the Elephant Butte Dam (San Acacia Reach)—92 mi (147 km) of river immediately downstream of the San Acacia Diversion Dam to the utility line crossing the Rio Grande just east of the Bosque Well demarcated on USGS Paraje Well 7.5 minute quadrangle (1980) with UTM coordinates of UTM Zone 13: 311474 E, 3719722 N.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Hybognathus amarus critical habitat consists of four components in New Mexico (68 FR 8088-8135):

(1) A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats, such as, but not limited to the following: Backwaters (a body of water connected to the main channel, but with no appreciable flow), shallow side channels, pools (that portion of the river that is deep with relatively little velocity compared to the rest of the channel), eddies (a pool with water moving opposite to that in the river channel), and runs (flowing water in the river channel without obstructions) of varying depth and velocity—all of which are necessary for each of the particular silvery minnow life-history stages in appropriate seasons (e.g., the silvery minnow requires habitat with sufficient flows from early spring (March) to early summer (June) to trigger spawning, flows in the summer (June) and fall (October) that do not increase prolonged periods of low or no flow, and a relatively constant winter flow (November through February)).

(2) The presence of eddies created by debris piles, pools, or backwaters, or other refuge habitat (e.g., connected oxbows or braided channels) within unimpounded stretches of flowing water of sufficient length (i.e., river miles) that provide a variation of habitats with a wide range of depth and velocities.

(3) Substrates of predominantly sand or silt.

(4) Water of sufficient quality to maintain natural, daily, and seasonally variable water temperatures in the approximate range of greater than 1 °C (35 °F) and less than 30 °C (85 °F) and reduce degraded conditions (e.g., decreased dissolved oxygen, increased pH).

Special Management Considerations or Protections

Section 3(5) of the Act defines critical habitat, in part, as areas within the geographical area occupied by the species ‘‘on which are found those physical and biological features (I) essential to the conservation of the species and (II) which may require special management considerations and protection.’’ We included lands of the Indian Pueblos of Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta in the proposed designation of critical habitat for the silvery minnow; however, Santo Domingo, Santa Ana, Sandia, and Isleta were not included for the final designation because they submitted sufficient management plans during the open comment period, and we concluded that these river reaches did not meet the definition of critical habitat because adequate special management is being provided for the silvery minnow on these lands. The plans and our analysis of other relevant issues are summarized above under the ‘‘Relationship of Critical Habitat to Pueblo Lands Under Section 3(5)(A) and Exclusions Under Section 4(b)(2)’’ section.

Life History

Feeding Narrative

Adult: Silvery minnow foraging strategies are often demersal (feeding along or near the river substrate) and primarily herbivorous (largely feeding on algae and other plant materials); this is indicated indirectly by the elongated and coiled gastrointestinal tract (Sublette et al. 1990); also Shirey (2004) and Magaña (2009) found diatoms (algae with cell walls made of silica) were a main component of their identifiable gut contents. Silvery minnows reared in a laboratory have been directly observed grazing on algae in aquaria (Platania 1995; Magaña 2009; USFWS 2010a). Additionally, in wild silvery minnows, organic detritus, larval insect exuvia, and small invertebrates, as well as sand, and silt are often filtered from the bottom and ingested (Sublette et al. 1990; USFWS 1999; Magaña 2009). The presence of this sand and silt in the gut of wild-captured specimens suggests that epipsammic algae (i.e., algae growing on surface of sand, such as species of diatoms) is an important food (Magaña 2009; USFWS 2010a). As silvery minnows age and grow, their feeding can include more prey variety (Pease et al. 2006; Magaña 2007).

Reproduction Narrative

Adult: Generally, a population of silvery minnows consists of only two age classes: Age-0 and Age-1 fish (USFWS 2010a; Horwitz et al. 2011). The majority of spawning silvery minnows is 1 year in age, with 2 year-old fish and older estimated to comprise less than 5 percent of the spawning population (USFWS 2010a). High mortality of silvery minnows occurs during or subsequent to spawning, consequently fewer adults have been found in late summer and fall. By December, in general, the majority of surviving silvery minnows are represented by Age-0 fish, those that hatched during the previous spring (Dudley and Platania 2007; Remshardt 2007, 2008a,b). Platania (1995a) found that a single female in captivity could broadcast 3,000 eggs in 8 hr. Females produce 3 to 18 clutches of eggs in a 12-hr period. The mean number of eggs in a clutch is approximately 270 (Platania and Altenbach 1998). In captivity, silvery minnows have been induced to spawn as many as four times in a year (Altenbach 2000). It is not known if they spawn multiple times in the wild. The high reproductive potential of this fish appears to be one of the primary reasons that it has not been extirpated from the Middle Rio Grande. However, the short life span of silvery minnows and environmental variation in their habitat increases the instability of the population. For example, when two below-average flow years occur consecutively, a short-lived species such as the silvery minnow can be impacted, if not eliminated from drying reaches of the Rio Grande (USFWS 1999, 2003a, 2010a).

Dependency on Other Individuals or Species for Habitat

Adult: `

Habitat Narrative

Adult: Habitat: Silvery minnows travel in schools and tolerate a wide range of habitats (Sublette et al. 1990), yet are commonly found in waters with low velocity (less than 10 centimeters per second [cm/s] (0.33 feet per second [ft/s])) in areas over silt or sand substrate associated with aquatic habitats such as shallow braided runs, backwaters, or pools (Dudley and Platania 1997, Watts et al. 2002). Habitat for silvery minnows includes stream margins (i.e., shoreline or shoal), side channels, and off-channel pools where water velocities are low or reduced. Stream reaches dominated by straight, narrow, incised channels with rapid flows are not typically occupied by silvery minnows (Sublette et al. 1990; Bestgen and Platania 1991). This preference for low velocity habitat, especially for survival and recruitment of larval and juvenile silvery minnows, characterizes the habitat use and recruitment conditions of most common native Rio Grande fishes (Pease et al. 2006). Passively drifting eggs and larvae are found throughout all habitat types, whereas adult silvery minnows are most commonly found in backwaters, pools, and habitats associated with debris piles, and young of year (YOY) (age-0) fish occupy shallow, low velocity backwaters with silt substrates (Dudley and Platania 1997). Dudley and Platania (1997) reported that silvery minnows were most commonly found in habitats with depths less than 50 cm (19.7 in). Over 85 percent were collected from low-velocity habitats (less than 10 cm/s [0.33 ft/s]) (Dudley and Platania 1997; Watts et al. 2002). During winter, silvery minnows tend to concentrate in low velocity areas in conjunction with vegetation or debris for cover, (Dudley and Platania 1996; Dudley and Platania 1997; Bixby and Burdett 2009). Silvery minnows are generally not found associated with cool water, cobble substrates, strong velocities, high salinity, highly channelized reaches, low oxygen conditions, or dry river bed areas (USFWS 2003a, 2003b; 2010, 2011a). Habitat for Reproduction: Silvery minnow is a pelagic spawner and a female may produce as many as 3,000 to 6,000 semibuoyant, nonadhesive eggs during a spawning event (Platania 1995; Platania and Altenbach 1998; Dudley and Platania 2008a). The majority of adults in the wild spawn in about a 1-month period in late spring to early summer (May to June) in association with spring runoff. Platania and Dudley (2000) found that the highest numbers of silvery minnow eggs collected from the river channel occurred in mid- to late May. These data suggest silvery minnow spawning events during the spring are concurrent with peak flows. Artificial flow spikes in spring have apparently induced silvery minnows to spawn (Platania and Hoagstrom 1996; USACE 2009). High spring flows, high water levels, and turbidity (i.e., particles preventing observation depth or spectra in the water column) generally preclude direct observations of silvery minnow spawning behavior and location(s) in the wild (Platania and Altenbach 1998; Caldwell 2003). In captivity, silvery minnows have been induced to spawn up to four times in a year (Altenbach 2000); however, it is unknown if individual silvery minnows spawn more than once per year in the wild or if multiple spawning events during spring and summer represent same or different individuals. The spawning strategy of releasing semibuoyant eggs can result in the downstream displacement of eggs, especially in years or locations where overbank-flooding opportunities are limited. The presence of irrigation water diversion dams (Angostura, Isleta, and San Acacia Diversion Dams) prevents the movement of adults to recolonize habitats upstream of these dams (Platania 1995) and has reduced the species' effective population size to critically low levels (Alò and Turner 2005; Osborne et al. 2005). Adults, eggs, and larvae may also be transported downstream and into to Elephant Butte Reservoir. It is believed that few to none of these fish survive because of poor habitat conditions and predation from reservoir fishes (USFWS 2010a). Also, silvery minnow eggs that enter Elephant Butte Reservoir may settle out along with substrate as velocity decreases in the delta area (i.e., where the river meets the reservoir) and subsequently suffocate as they are buried with silt and sediment (Platania and Altenbach 1998, p. 55). Platania (2000) found that development of larval fish and hatching of eggs are correlated with water temperature. Eggs of silvery minnows raised in water at 30 °C (86 °F) hatched in approximately 24 hr while eggs reared in 20 to 24°C (70 to 75 °F) water hatched within 50 hr. Eggs were 1.52 mm (0.06 in) in diameter upon fertilization, but quickly swelled to 3.05 mm (0.12 in) during water exposure. Salinity and suspended sediment may affect the specific gravity of silvery minnow eggs, potentially affecting their survival and rate of downstream transport (Cowley et al. 2009). Recently hatched larval fish are about 3.81 mm (0.15 in) in standard length and grow about 0.13 mm (0.005 in) per day during development though various larval stages. Eggs and larvae have been estimated to remain in the drift for 3 to 5 days, and could be transported from 216 to 359 km (134 to 223 mi) downstream depending on river flows, obstructions to flow, and availability of nursery habitat (Platania and Dudley 2000; Fluder et al. 2007). Approximately 3 days after hatching the larvae move to low velocity habitats where food (mainly algae (i.e. phytoplankton) and small animals (i.e. zooplankton)) is abundant (Pease et al. 2006). The Age-0 fish attain lengths of 39 to 41 mm (1.53 to 1.61 in) by late autumn (USFWS 2010a). Age-1 fish are approximately 46 mm (1.8 in) by the start of the spring spawning season. Most growth occurs between June (post spawning) and October, but there is some growth during the winter months. Maximum longevity is about 30 months for wild fish (inferred from length-frequency), or up to 36 months based on findings from a study of otolith and scale examinations on wild fish (Horwitz et al. 2011), and up to 36 months for hatchery-released fish (USFWS 2010a). In laboratory experiments, Bestgen et al. (2010) found that adult silvery minnow are capable of relatively high-speed and long-distance swimming. Mean critical swimming speed for silvery minnows was 51.5 cm/s, with faster sustained swimming speeds for larger fish. Silvery minnow were capable of swimming for longer durations at lower water velocities and warmer water temperatures. Endurance is a function of significant effects of water velocity, water temperature, and fish total length. Individual have the ability to swim several kilometers is just a few hours (up to 125 km) and are capable of moving long distances upstream as part of their life history. In 2006, the Service's New Mexico Fish and Wildlife Conservation Office conducted an experimental study of stocking success for silvery minnows reared in captive propagation facilities and released throughout their current range. The data from this study provided addition information on movement of hatchery reared silvery minnows following their release. The recapture data indicated that movement was generally downstream, with the majority of recaptures within 16 to 24 km (10 to 15 mi) downstream of the release site. The maximum distance traveled from release to recapture was 59.4 km (36.9 mi) downstream 300 days following release. Upstream movement was minimal; however, some individuals were documented upstream from their release sites. The maximum upstream distance traveled was 37.7 km (23.4 mi) 246 days following release (Remshardt and Archdeacon 2011). Based on estimated length groups for assigning an age class, it is possible that some individuals in the wild survive to be Age-3 fish; however greater than 95 percent of the population in any given year is estimated to comprise Age-0 and Age-1 fish (USFWS 2010a). In the wild, the silvery minnow is a very short-lived species that exhibits similar patterns of growth, survival, and longevity as compared with several other closely related species of Hybognathus (Horwitz et al. 2011). In comparison to longevity in the wild, it is common for captive-reared, silvery minnows to live beyond 4 years, especially at lower water temperatures. For example, the USGS Columbia Environmental Research Center research station in Yankton, South Dakota, has several silvery minnows in captivity with a maximum age of 11 and that range in size from 46 to 73 mm (1.8 to 2.9 in) standard length (USFWS 2010a).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant

Population Information and Trends

Population Narrative:

Since 2006, the Middle Rio Grande Endangered Species Collaborative Program (MRGESCP) has funded studies to investigate methods for estimating population size for the Rio Grande silvery minnow (Dudley et al. 2011a,b,c, 2012b). This study was structured to provide estimation for the population of Rio Grande silvery minnow based on data collected from 20 sampling units in the study area. Sampling units were selected randomly using a spatially balanced statistical design to maintain an unbiased probability of sampling at localities that support differing densities of silvery minnow. The 2008 estimate incorporated sampling efficiencies by habitat and is considered the most reliable estimate to date. In 2008, silvery minnow numbers were highest in the Isleta Reach (N = 1,027,489) and lowest in the San Acacia Reach (N = 404,864). In October 2009, population estimates were highest in the Isleta Reach (N = 1,602,348) and lowest in the San Acacia Reach (N = 923,352). The total population estimate for all three reaches was 3,476,873 (Dudley et al. 2011b). In October 2010, the overall population estimate decreased to 267,272 for all three reaches (Dudley et al. 2011c). The 2011 population estimation data suggested that the silvery minnow population declined as compared with 2010 (Dudley et al. 2012b) and undoubtedly declined further in 2012 as indicated by the lack of detection during population monitoring of silvery minnows in the San Acacia Reach (Dudley et al. 2012a). Genetics The ability of a species to persist long term is determined in part by the amount of genetic variation that is retained by a species. As a population declines, genetic variation is lost and can lead to reduced viability and reproductive capability (Falconer 1981, Ralls and Ballou 1983), affect a species' ability to adapt and respond to environmental changes, and can ultimately heighten the risk of extinction (Frankham 1995, Higgins and Lynch 2001). Evaluations of genetic data collected for the Rio Grande silvery minnow indicate that overall, mitochondrial (mt) DNA diversity declined nearly 18 percent between 1987 and 2005. There have been two sharp declines in mt DNA diversity in the "wild" Rio Grande silvery minnow population. The first occurred in 1999, the second in 2001 (Alò and Turner 2005, Turner et al. 2006, Turner and Osborne 2007). The losses of diversity followed a sharp decline in abundance of Rio Grande silvery minnow between 1995 and 1997, and again between 1999 and 2000, as catch rates declined by an order of magnitude (Dudley et al. 2005). These declines in diversity coincided with extensive drying in the San Acacia Reach of the Rio Grande. Mitochondrial DNA diversity has continued to decline between 2004 and 2007 (Turner and Osborne 2007). Declines in heterozygosity were also recorded for silver minnow from 1987 to 1999 and between 2000 and 2002, but increased between 2002 and 2005. Supplemental stocking with captively reared minnows from wild-caught eggs between 2001 and 2003 is thought to have temporarily alleviated loss of alleles and heterozygosity in the wild during this period (Turner and Osborne 2004). Heterozygosity again declined in 2007 (Turner and Osborne 2007). Genetic studies have also demonstrated that the effective population size (Ne) for the Rio Grande silvery minnow is a fraction of the census size (Alò and Turner 2005). The effective population size is defined as the number of adult individuals that successfully contribute genes to subsequent generations (Frankham 1995). Alternatively, put into other words, the effective population size is a measure that allows predictions about the rate of loss of genetic variation in a population and is generally equivalent to the number of individuals that contribute genes to subsequent generations. In natural population, Ne is less than the census population size, which is the actual number on individuals that can be counted (Frankham 1995). For the Rio Grande silvery minnow, the presence of diversion dams prevents the recolonizaiton of upstream habitats (Platania 1995) and has reduced the species' effective population size to critically low levels (Alò and Turner 2005). The Ne for the silvery minnow is estimated to be approximately 100 and calculated from measured genetic changes (due to genetic drift) across nine generations. Although the Service does not know the direct impacts of small genetic effect size in silvery minnow, the rate at which genetic diversity is lost is inversely proportional to effective population size. There is ample indication that populations of species that have limited diversity are at increased extinction risk. In conservation genetics literature, an Ne of 500 has been recommended to conserve neutral genetic variation (Frankel and Soule 1981) and an Ne of 5000 has been recommended to maintain the normal adaptive potential in important traits, such as size, that are determine by multiple genes (Lande 1995). Estimates of genetic effective size for the Rio

Grande silvery minnow have consistently fallen well below the lower of these numbers, and the current effective size is not sufficient to rule out genetic consequences of small Ne for the species.

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative: 1. regulation of stream waters, which has led to severe flow reductions, often to the point of dewatering extended lengths of stream channel.

Stressor:
Exposure:
Response:
Consequence:
Narrative: 2. alteration of the natural hydrograph, which impacts the species by disrupting the environmental cues the fish receives for a variety of life functions, including spawning as well as food availability during larval fish development;

Stressor:
Exposure:
Response:
Consequence:
Narrative: 3. both the stream flow reductions and other alterations of the natural hydrograph throughout the year can severely impact habitat availability and quality, including the temporal availability of habitats;

Stressor:
Exposure:
Response:
Consequence:
Narrative: 4. actions such as channelization, bank stabilization, levee construction, and dredging result in both direct and indirect impacts to the silvery minnow and its habitat by severely disrupting natural fluvial processes throughout the floodplain;

Stressor:
Exposure:
Response:
Consequence:
Narrative: 5. construction of diversion dams fragment the habitat and prevent upstream migration;

Stressor:
Exposure:
Response:
Consequence:

Narrative: 6. introduction of nonnative fishes that directly compete with, and can totally replace the silvery minnow, as was the case in the Pecos River, where the species was totally replaced in a time frame of 10 years by its congener the plains minnow (H. placitus); and,

Stressor:
Exposure:
Response:
Consequence:
Narrative: 7. degraded water quality caused by industrial, municipal, or agricultural discharges also affects the species and its habitat (USFWS 1994).

Stressor: Decreased water volume (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Decreased water volume also puts stress on partitioning of water for human consumption and maintaining habitat for the silvery minnow. Climate change is also causing reduction in water available for agricultural use (Mubako et al. 2018; Samimi et al. 2022). Three main diversion dams fragment the MRG into three distinct reaches and provide water to farmers for irrigation. During the summer months of baseflow the Rio Grande often dries in the two southern reaches of the MRG and we are starting to see drying in all reaches occupied by minnow (River Eyes Monitoring Program Webpage). As climate change and demand for irrigation continues, baseflows are likely to decrease resulting in an increase in river drying every year. Decreases in magnitude and duration of spring run-off reduce the water necessary for spawning and recruitment of silvery minnow (U.S. Fish and Wildlife Service 2010). Decreases in baseflow also equate to a reduction in critical habitat necessary for silvery minnow survival (USFWS, 2023)

Recovery

Reclassification Criteria:
Downlisting (Goal 2) of the silvery minnow may be considered when the criteria have been met resulting in three populations (including at least two that are self-sustaining) that have been established within the historical range of the species and have been maintained for at least 5 years.

Delisting Criteria:
Delisting (Goal 3) of the species may be considered when the criteria have been met resulting in three self-sustaining populations have been established within the historical range of the species and have been maintained for at least 10 years (USFWS 2010a).

Recovery Actions:

- Recovery efforts are currently guided by the First Revision of the Rio Grande Silvery Minnow Recovery Plan, which was finalized and issued on February 22, 2010 (75 FR 7625, USFWS 2010a). The revised Recovery Plan describes recovery goals for the silvery minnow and actions to complete these (USFWS 2010a). The three goals identified for the recovery and delisting of the silvery minnow are: 1. prevent the extinction of the silvery minnow in the Middle Rio Grande of New Mexico; 2. recover the silvery minnow to an extent sufficient to change its status on the List of Endangered and Threatened Wildlife from endangered to threatened (downlisting); and 3. recover the silvery minnow to an extent sufficient to remove it from the List of Endangered and Threatened Wildlife (delisting).

- We recommend that the Rio Grande Silvery Minnow remain listed as an endangered species with a listing priority of 2C (USFWS, 2018).
- Conservation and recovery efforts targeting the silvery minnow are also summarized in the revised Recovery Plan and elsewhere (Tetra Tech EM Inc. 2004; USFWS 2010a). These efforts have included habitat restoration activities; research and monitoring of the status of the silvery minnow, its habitat, and the associated fish community in the Middle Rio Grande; and programs to stabilize and enhance the species, such as tagging fish and egg monitoring studies, salvage operations, captive propagation, fish health monitoring, and augmentation efforts (for more information see www.middleriogrande.com). In addition, specific water management actions in the Middle Rio Grande valley over the past several years have been used to meet river flow targets and the 2003 BO requirements for silvery minnow (USFWS 2003a). Propagation and Augmentation In 2000, the Service identified captive propagation as an appropriate strategy to assist in the recovery of the silvery minnow. Captive propagation is conducted in a manner that will, to the maximum extent possible, preserve the genetic and ecological distinctiveness of the silvery minnow and minimize risks to existing wild populations. Facilities at Dexter National Fish Hatchery and Technology Center and the City of Albuquerque's BioPark conduct captive propagation of silvery minnows. Silvery minnows are also held at the Service's New Mexico Fish and Wildlife Conservation Office, the Interstate Stream Commission Refugium in Los Lunas, New Mexico, and USGS Columbia Environmental Research Center Laboratory in Yankton, South Dakota. Since 2002, over 1 million silvery minnows have been propagated and released into the Rio Grande (Remshardt 2010b). Wild gravid adults are successfully spawned in captivity at the City of Albuquerque's propagation facilities. Eggs are raised and released as larval fish. Marked fish have been released into the Middle Rio Grande by the Service's New Mexico Fish and Wildlife Conservation Office, and others, since 2002 under an augmentation effort funded by the Middle Rio Grande Endangered Species Collaborative Program. Eggs left in the wild have a very low survivorship, and captive propagation ensures that an adequate number of spawning adults are present to repopulate the river each year. Wild eggs are also collected and reared to maximize the genetic diversity of the minnows released (Remshardt 2008b; Osborne et al. 2012). Silvery Minnow Salvage and Relocation During river drying, staff from the Service's New Mexico Fish and Wildlife Conservation Office often captures and relocates silvery minnows to nearby perennial water (Remshardt 2010a,b). Through 2009, approximately 800,000 silvery minnows have been rescued and relocated to wet river reaches, the majority of which were released in the Angostura Reach. Studies have been conducted to determine survival rates for salvaged fish. Caldwell et al. (2010) reported on studies that assessed the physiological responses of wild silvery minnows subjected to collection and transport associated with salvage. The authors examined primary (plasma cortisol), secondary (plasma glucose and osmolality), and tertiary indices (parasite and incidence of disease) and concluded that the effects of stressors associated with river intermittency and salvage resulted in a cumulative stress response in wild silvery minnows. They also concluded that fish in isolated pools experienced a greater risk of exposure and vulnerability to pathogens (parasites and bacteria), and that the stress response and subsequent disease effects were reduced through a modified salvage protocol that applied specific criteria to determine which wild fish are to be rescued from pools during river intermittency (Caldwell et al. 2010).

- ADDITIONAL RECOMMENDATIONS FOR FUTURE ACTIONS While extensive and diverse management efforts over the past two decades have provided invaluable protection against the extirpation of Rio Grande Silvery Minnow, ongoing and planned efforts (e.g., restoring dynamic river flows, reconnecting fragmented reaches, and reestablishing a functional floodplain) should help to promote resilient and selfsustaining populations of this imperiled species (Dudley et al. 2018). Recovery efforts should focus on ensuring prolonged and elevated spring flows resulting in overbank flooding, formation of inundated habitats within the river channel, and creation of shoreline pools and backwaters. Continued efforts to provide reasonable spring spawning and summer survival conditions will be essential for securing a self-sustaining wild population of Rio Grande Silvery Minnow in the MRG (Dudley et al. 2018). Complete fish passage at Angostura Diversion Dam and reach agreements with affected Native American Pueblos for Rio Grande Silvery Minnow management during drought. Design and support a National Academy of Sciences Study on Reservoir Operations in Upper Rio Grande Basin to evaluate the legal and operational flexibilities necessary to store, release, and time water to create essential peak and sustained flows in the Middle Rio Grande for the benefit of the riparian environment and Rio Grande Silvery Minnow. Evaluate storing water in upstream reservoirs. (Guardians-Defenders 2018). Develop a collaborative Species Status Assessment with the State of New Mexico that can provide a comprehensive reevaluation of threats in the MRG considering the expanded body of science concerning the silvery minnow (NMISC 2018). Conduct comprehensive instream flow assessments in the Middle Rio Grande to determine the optimum and minimum flows necessary, by season, to support habitat, life history needs, and recovery of the Rio Grande Silvery Minnow as part of the River Integrated Operations Adaptive Management Strategy (USBR 2015; USFWS 2016). Continue to seek reestablishment of resilient populations of this species at other locations within its historical range to further ensure its long-term persistence in the wild. Evaluate the conditions attributable to the lack of a self-sustaining population in the Big Bend area. Strengthen independent peer review process (across agencies) to remove stakeholder bias, safeguard scientific integrity, and ensure that fish sampling data continues to further survival and recovery actions and during fish monitoring (Guardians-Defenders 2018). Use flow assessments to develop a program to protect instream flows for listed species under state law, acquire water, and enforce such flows (Guardians-Defenders 2018). Conduct a comprehensive plan and environmental review for decommissioning the lowflow conveyance channel in the San Acacia Reach of the Middle Rio Grande to return the Rio Grande to a one-channel system to restore river flows (Guardians-Defenders 2018) (USFWS, 2018).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Future recommendations for silvery minnow conservation include, but are not limited to: • Implementing the high priority recovery actions. Priority actions should be determined by the USFWS in congruence with the needs from other agencies and partners (e.g., US Bureau of Reclamation, NM Interstate Stream Commission, Middle Rio Grande Conservation District, and non-governmental organization biologists to ensure that partner needs as well as species needs are being met • Utilize current, available data to assess water use and species management within the MRG to attain a self-sustaining population • Develop tools or resources to secure water for environmental purposes. Develop water rights/uses for the MRG to manufacture a spring pulse if snowpack cannot provide a large enough pulse to induce spawning. Secure water storage for times of drought conditions to use for recruitment and to mitigate drying during the spring and summer. • Increase capacity at fish facilities to raise silvery minnows. We currently do not have the capacity to raise enough minnows to support a population outside of the MRG (USFWS, 2023).

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SPECIES ACCOUNT: *Hypomesus transpacificus* (Delta smelt)

Species Taxonomic and Listing Information

Listing Status: Threatened; March 5, 1993 (58 FR 12854).

Physical Description

The delta smelt (Hypomesus transpacificus) is a member of the Osmeridae family. Individuals have slender bodies and are generally about 60 to 70 millimeters (mm) (2 to 3 inches [in.]) in length. They are nearly translucent and have a steely blue sheen to their sides. They are also identifiable by their relatively large eye-to-head size. The eye can occupy approximately 25 to 30 percent of their head length. Delta smelt have a small, translucent adipose fin between the dorsal and caudal fins. Occasionally, one chromatophore (a small, dark spot pigmentation) may be found between the mandibles, but most often there is none (USFWS 2015).

Taxonomy

The delta smelt is one of six species currently recognized in the Hypomesus genus (USFWS 2015). Within the genus, delta smelt is most closely related to surf smelt (H. pretiosis), a species common along the western coast of North America (USFWS 2015). In contrast, delta smelt is a comparatively distant relation to the wakasagi (H. nipponensis), which was introduced into Central Valley reservoirs in 1959, and may be seasonally sympatric with delta smelt in the estuary. Allozyme studies have demonstrated that wakasagi and delta smelt are genetically distinct and presumably derived from different marine ancestors. Genetic characterization of delta smelt, longfin smelt, and wakasagi is presently under investigation, using contemporary methodologies (75 FR 17667).

Historical Range

Delta smelt historically occurred in Contra Costa, Sacramento, San Joaquin, Solano, and Yolo counties in California. The delta smelt historical range is thought to have extended from San Pablo Bay upstream to at least the city of Sacramento on the Sacramento and the city of Mossdale on the San Joaquin River. They were once one of the most common pelagic (living in open water away from the bottom) fish in the upper Sacramento-San Joaquin estuary (USFWS 2015).

Current Range

Delta smelt are endemic to the San Francisco Bay and Sacramento-San Joaquin estuary (Delta) in California. They occur in the Delta primarily below Isleton on the Sacramento River, below Mossdale on the San Joaquin River, and in Suisun Bay. They move into freshwater when spawning (ranging from January to July) and can occur in: (1) the Sacramento River as high as Sacramento; (2) the Mokelumne River system; (3) the Cache Slough region; (4) the Delta, and; (5) the Montezuma Slough area of the estuary. During high outflow periods, they may be washed into San Pablo Bay, but they do not establish permanent populations there. Since 1982, the center of delta smelt abundance has been the northwestern Delta in the channel of the Sacramento River. However, high outflows in the winter of 1992 to 1993 allowed delta smelt to recolonize Suisun Bay in 1993. Delta smelt are captured seasonally in Suisun Marsh. When not spawning, they tend to be concentrated in the mixing zone, where incoming saltwater and outflowing freshwater mix (USFWS 1996).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 12/19/1994.

Legal Description

On December 19, 1994, the Fish and Wildlife Service (Service) designated critical habitat for the threatened delta smelt (Hypomesus transpacificus) pursuant to the Endangered Species Act of 1973, as amended (Act) (16 U.S.C. 1531 et seq.). The final rule designates critical habitat for the delta smelt in the following geographic areas—areas of all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear. Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the Delta, as defined in section 12220 of the California Water Code.
Critical habitat designation for the delta smelt will provide additional protection under section 7 of the Act with regard to activities that require Federal agency action.

Critical Habitat Designation

The critical habitat designation for Hypomesus transpacificus includes areas of all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the Delta, California.

California—Areas of all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and HonkerBays); the length of Montezuma Slough, and the existing contiguous waters contained within ti:e Delta, as defined by section 12220, of the State of California's WaterCode of 1969 (a conplex of bays, dead-end sloughs, channels typically less than 4 meters deep, marshlands, etc.) as follows: Bounded by a line beginning at the Carquinez Bridge which crosses the Carquinez Strait: thence, northeasterly along the western and northern shoreline of Suisun Bay, including Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma Sloughs; thence, upstream to the intersection of Montezuma Slough with the western boundary of the Delta as delineated in section 12220 of the State of California's Water Code of 1969; thence, following the boundary and including all contiguous water bodies contained within the statutory definition of the Delta, to its intersection with the San Joaquin River at its confluence with Suisun Bay: thence, westerly along the south shore of Suisun Bay to the Carquinez Bridge.

Primary Constituent Elements/Physical or Biological Features

The primary constituent elements for the delta smelt are:

Spawning Habitat—Delta smelt adults seek shallow, fresh or slightly brackish backwater sloughs and edgewaters for spawning. To ensure egg hatching and larval viability, spawning areas also must provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emergent vegetation). Specific areas that have been identified as important delta smelt spawning habitat include Barker, Lindsey, Cache, Prospect, Georgiana, Beaver, Hog, and Sycamore sloughs and the Sacramento River in the

Delta, and tributaries of northern Suisun Bay. The spawning season varies from year to year and may start as early as December and extend until July.

Larval and Juvenile Transport—To ensure that delta smelt larvae are transported fromthe area where they are hatched to shallow, productive rearing or nursery habitat, the Sacramento and San Joaquin Rivers and their tributary channels must be protected from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g.. water diversions that result in entrainment and in-channel barriers or tidal gates). Adequate river flow is necessary to transport larvae from upstream spawning areas to rearing habitat in Suisun Bay. Additionally, river flow must be adequate to prevent interception of larval transport by the State and Federal water projects and smaller agricultural diversions in the Delta. To ensure that suitable rearing habitat is available in Suisun Bay, the 2 ppt isohaline mustbe located westward of the Sacramento-San Joaquin River confluence during the period when larvae or juveniles are being transported, according to the historical salinity conditions which vary according to water-year type. Reverse flows that maintain larvae upstream in deep-channel regions of low productivity and expose them to entrainment interfere with those transport requirements. Suitable water quality must be provided so that maturation is not impaired by pollutant concentrations. The specific geographic area important for larval transport is confined to waters contained within the legal boundary ofthe Delta, Suisun Bay, and Montezuma Slough and its tributaries. The specific season when habitat conditions identified above are important for successful larval transport varies from yearto year, depending on when peak spawning occurs and on the water-year type. The Service identified situations in the biological opinion for the delta smelt (1994) where additional flows might be required in the July— August period to protect delta smelt that were present in the south and central Delta from being entrained in the State and Federal project pumps, and to avoid jeopardy to the species. The long-term biological opinion on CVP—SWP operations will identify situations where additional flows may be required after the February through June period identified by EPA for its water quality standards to protect delta smelt in the south and central Delta.

Rearing Habitat—Maintenance of the 2 ppt isohaline according to the historical salinity conditions described above and suitable water quality (low concentrations of pollutants) within the Estuary is necessary to provide delta smelt larvae and juveniles a shallow. protective, food-rich environment in which to mature to adulthood. This placement of the 2 ppt isohaline also serves to protect larval, juvenile, and adult delta smelt from entrainment in the State and Federal water projects. An area extending eastward from Carquinez Strait, including Suisun Bay, Grizzly Bay, Honker Bay, Montezuma Slough and its tributary sloughs, up the Sacramento River to its confluence with ThreeMile Slough, and south along the San Joaquin River including Big Break, defines the specific geographic area critical to the maintenance ofsuitable rearing habitat. Three Mile Slough represents the approximate location of the most upstream extent of tidal excursion when the historical salinity conditions describedabove are implemented. Protection of rearing habitat conditions may be required from the beginning of February through the summer.

Adult Migration—Adult delta smelt must be provided unrestricted access to suitable spawning habitat in a period that may extend from December to July. Adequate flow and suitable water quality may need to be maintained to attract migrating adults in the Sacramento and San Joaquin River channels and their associated tributaries, including Cache and Montezuma sloughs and their tributaries. These areas also should be protected from physical disturbance and flow disruption during migratory periods.

Special Management Considerations or Protections

Five activities that, depending on the season of construction and scale of the project, might result in the destruction or adverse modification of critical habitat without necessarily jeopardizing the continued existence of the delta smelt. These activities are: (1) Sand and gravel extraction in river channels or marshes; (2) Diking wetlands for conversion to farmland and dredging to maintain these dikes; (3) Levee maintenance and bank protection activities, such as riprapping, removal of vegetation, and placement of dredged materials on levees of banks; (4) Operation ofthe Montezuma Slough Control Structure; and (5)Bridge and marina construction. Construction and implementation of each of these five actions requires authorization by the Army Corps of Engineers (Corps) pursuant to section 10 of the Rivers and Harbors Act of 1899 and section 404 of the CWA and therefore are considered Federal actions.

Life History

Feeding Narrative

Juvenile: See Adult narrative.

Adult: Juvenile delta smelt are opportunistic invertivores that feed exclusively on larval copepods. When delta smelt reach approximately 13 mm (0.5 in.) in length, they switch from consuming larval copepods to consuming mostly adult copepods (Nobriga 2002). Adult delta smelt feed primarily on small planktonic (free-floating) crustaceans, and occasionally on insect larvae (USFWS 2015). Historically, the main prey of delta smelt was the copepod Eurytemora affinis and the mysid shrimp (Neomysis mercedis) (USFWS 2015). The slightly larger copepod Pseudodiaptomus forbesi has replaced E. affinis as a major prey source of delta smelt since its introduction into the San Francisco Bay-Delta (USFWS 2015). Two other copepod species, Limnoithona tetraspina and Acartiella sinenisi, have become abundant since their introduction to the San Francisco Bay-Delta in the mid-1990s (USFWS 2015). Delta smelt eat these introduced copepods, but P. forbesi remains a dominant prey item. Delta smelt are thought to require a turbid environment for efficient, successful foraging (USFWS 2015). The foraging success of delta smelt varies between years, and depends on their location in the estuary (Lott 1998).Juvenile delta smelt grow rapidly, reaching 40 to 50 mm (1.6 to 2 in.) in length by early August (USFWS 1996). Delta smelt reach 55 to 70 mm (2.2 to 2.8 in.) in standard length in 7 to 9 months (USFWS 1996). Growth over the next 3 months slows considerably; individuals only grow an additional 3 to 9 mm (0.1 to 0.4 in.) total, presumably because most energy is directed toward gonadal development (USFWS 1996). Nonnative competitors of the delta smelt include the overbite clam (Corbula amurensis) and the Mississippi silverside (Menidia audens) (USFWS 2015).

Reproduction Narrative

Juvenile: See Adult narrative.

Adult: Delta smelt are broadcast spawners that breed from late January through late June or early July at water temperatures ranging from 7 to 20 degrees °C (44.6 to 71.6 degrees °F) (USFWS 2015). Spawning typically occurs in freshwater, although it can sometimes occur in slightly brackish water (NatureServe 2015). Most spawning occurs in sloughs and shallow edge-waters of channels in the upper Delta, including Barker Slough, Lindsey Slough, Cache Slough, Georgiana Slough, Prospect Slough, Beaver Slough, Hog Slough, and Sycamore Slough, as well as in the Sacramento River above Rio Vista (USFWS 1996). Females between 59 and 70 mm (2.3 to 2.8 in.) in standard length lay 1,200 to 2,600 eggs (USFWS 1996). Most delta smelt live for about 1 year and die after spawning, but a small contingent of adults survives and can spawn in their second year (USFWS 2015).Eggs are demersal (sink to the bottom) and adhesive, sticking to hard substrates such as rock, gravel, tree roots, submerged branches, and submerged vegetation (USFWS 1996). Eggs typically hatch after 9 to 14 days, and larvae begin feeding 5 to 6 days later (USFWS 2015). Larvae are generally most abundant in the Delta from mid-April through May, and juvenile delta smelt reach adulthood in September and October at approximately 6 to 7 months of age (USFWS 2015).

Geographic or Habitat Restraints or Barriers

Juvenile: Same as Adult.

Adult: Do not occur in water more saline than 12 ppt (NatureServe 2015).

Spatial Arrangements of the Population

Juvenile: Juvenile smelt are found in relatively shallow open water habitat (USFWS 2015).

Adult: Clumped; form schools in the open surface waters of the Delta and Suisun Bay (USFWS 1996). When not spawning, delta smelt tend to concentrate where salt and freshwater mix (salinity about 2 ppt) and zooplankton populations are dense (NatureServe 2015).

Environmental Specificity

Juvenile: Same as Adult.

Adult: Community with key requirements common.

Tolerance Ranges/Thresholds

Juvenile: Same as Adult.

Adult: High; see "Additional Threshold Info" section.

Site Fidelity

Juvenile: Same as Adult.

Adult: Low

Habitat Narrative

Juvenile: See Adult narrative.

Adult: Delta smelt occur at the interface of brackish water and freshwater in the open waters of bays, tidal rivers, channels, and sloughs (NatureServe 2015). Compared to adults, juvenile delta smelt tend to occupy shallower open water habitat (USFWS 2015). Adults form schools in the open surface waters of the Delta and Suisun Bay (USFWS 1996). Habitat is most suitable for delta smelt when low-salinity water (typically about 2 ppt, almost always less than 12 ppt) is near 20°C (68°F), highly turbid, oxygen saturated, and low in contaminants, and supports high densities of calanoid copepods and mysid shrimp (USFWS 2015). Delta smelt likely evolved in the naturally turbid (silt and particulate-laden) environment of the Delta and likely rely on certain levels of background turbidity at different life stages and for certain behaviors (USFWS 2015). For example, laboratory studies found that delta smelt larval feeding increased with increased turbidity (USFWS 2015). Adequate freshwater flows are needed to transport young to rearing habitat and to maintain rearing habitat in a favorable location (NatureServe 2015). The area of the 2 ppt isohaline is an important rearing habitat for young delta smelt (NatureServe 2015).

Dispersal/Migration

Motility/Mobility

Juvenile: High; after several weeks of development, larvae move downstream until they reach nursery habitat in the low salinity zone (LSZ), where the salinity ranges from 0.5 to 7 ppt (USFWS 2015).

Adult: High; after reaching adulthood in September and October, adult delta smelt gradually move from the LSZ back into freshwater areas where spawning is thought to occur (USFWS 2015).

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Seasonal movement, larvae move downstream to nursery habitat in the LSZ (USFWS 2015).

Adult: Seasonal movement; shortly before spawning, migrates upstream to spawning habitat (NatureServe 2015).

Dispersal

Adult: N/A; the species is represented by what can be regarded as one large occurrence. Individuals move seasonally to and from breeding habitat, but cannot disperse to other populations because there is effectively one population (NatureServe 2015).

Immigration/Emigration

Juvenile: No

Adult: No

Dependency on Other Individuals or Species for Dispersal

Juvenile: No

Adult: No

Dispersal/Migration Narrative

Juvenile: See Adult narrative.

Adult: Delta smelt are highly mobile. After reaching adulthood in September and October, adults move from the LSZ to freshwater areas to spawn, and larvae (16 to 18 mm [0.6 to 0.7 in.] in length) are washed downstream from freshwater areas to rearing habitat in the LSZ, where salinity ranges from 0.5 to 7 ppt (USFWS 2015). Juvenile smelt rear and grow in the LSZ for several months before reaching adulthood and moving upstream (USFWS 2015). Because the species is represented by what can be regarded as one large occurrence, individuals cannot disperse to facilitate gene flow between populations (NatureServe 2015).

Additional Life History Information

Juvenile: Larvae (16 to 18 mm [0.6 to 0.7 in.] in length) are presumably washed downstream until they reach the mixing zone or the area immediately upstream of it (USFWS 1996). Juvenile smelt rear and grow in the LSZ for several months (USFWS 2015).

Population Information and Trends

Population Trends:

Decreasing (USFWS 2015)

Species Trends:

Decreasing (USFWS 2015)

Number of Populations:

One; species represented by what can be regarded as one large occurrence (NatureServe 2015).

Population Size:

The fall midwater trawl (FMWT), which provides an index of delta smelt relative abundance, ranged from a low of 7 in 2015 to 1,673 in 1970 (SWG 2015; USFWS 2015).

Resistance to Disease:

Low

Adaptability:

Low

Additional Population-level Information:

Delta smelt were once one of the most common pelagic fish in the upper Sacramento-San Joaquin estuary (USFWS 1996).

Population Narrative:

Delta smelt were once one of the most common pelagic fish in the upper Sacramento-San Joaquin estuary (USFWS 1996). The species appeared to decline abruptly in the early 1980s, then rebounded somewhat in the mid-1990s (USFWS 2015). However, delta smelt numbers have trended precipitously downward since the early 2000s and continue to fall (USFWS 2015). From 2003 to 2012, the species fell in abundance to the lowest on record, and a 2005 population viability analysis calculated a 50 percent likelihood that the species could reach effective extinction within 20 years (NatureServe 2015; USFWS 2010).The Interagency Ecological Program conducts several field investigations that provide annual delta smelt abundance information, including the FMWT. The FMWT provides the best available long-term index of the relative abundance of delta smelt, but does not presently support statistically reliable population abundance estimates. Instead, the FMWT-derived data provide a basis for detecting and roughly scaling interannual trends in delta smelt abundance. The FMWT-derived indices have ranged from a low of 7 in 2015 to 1,673 in 1970 (USFWS 2015).

Threats and Stressors

Stressor: Reduced freshwater outflow
Exposure: Reduced Delta inflow/outflow; dams and canals.
Response: Migration of the LSZ; changes in amount of habitat; increased competition and predation; and increased entrainment.
Consequence: Reduced abundance.
Narrative: From late spring through fall and early winter, delta smelt occur in the LSZ, whose geographic location varies with Delta water outflow. Reduced Delta outflow causes the LSZ to move upstream, which concentrates delta smelt in a small area along with other competing planktivorous fishes. Causes of such reduced outflows include changes in timing and volume of releases from upstream dams, delta water exports at the state and federal diversion facilities, and upstream water diversions. Low freshwater outflows in the fall have been correlated with a reduced abundance index for young delta smelt the following summer (USFWS 2015).

Stressor: Climate change
Exposure: Increased water temperature, altered hydrology, and changes in frequency of extreme events associated with climate change.
Response: Potential alteration of the timing or magnitude of migration and spawning cues, and potential for spawning habitat to be located further upstream.
Consequence: Reduction in spawning success.
Narrative: Effects of climate change could be particularly profound for aquatic ecosystems; they include increased water temperatures and altered hydrology, along with changes in the extent, frequency, and magnitude of extreme events such as droughts, floods, and wildfires. Numerous climate models predict changes in precipitation frequency and patterns in the western United States. Projections indicate that temperature and precipitation changes will diminish snowpack, changing the availability of natural water supplies. Warming may result in more precipitation falling as rain and less as snow, resulting in increased rain-on-snow events and increased winter runoff as spring runoff decreases. It is uncertain how a change in the timing and duration of freshwater flows will affect delta smelt. The melting of snowpack earlier in the year could result in higher flows in January and February, ahead of peak spawning and hatching months for delta smelt. This could alter the timing or magnitude of migration and spawning cues, and potentially result in decreased spawning success. As the freshwater boundary moves farther inland into the Delta with increasing sea level and reduced flows, adults will need to migrate farther into the Delta to spawn, increasing the risk of predation and the potential for entrainment into water export facilities and diversions for both themselves and their progeny (USFWS 2015).

Stressor: Turbidity
Exposure: Interruption of sediment transport by upstream dams and spread of Brazilian waterweed.
Response: Reduced foraging efficiency and increased risk of predation.
Consequence: Decreased foraging efficiency and increased risk of predation.
Narrative: Delta smelt are believed to require relatively turbid waters to capture prey and avoid predators. From 1999 to present, the Delta has experienced a decline in turbidity that culminated in an estuary-wide step-decline in 1999. The increased water clarity in delta smelt rearing habitat in recent decades is attributed to the interruption of sediment transport by upstream dams and the spread of the exotic invasive water plant Brazilian waterweed (Egeria densa), which traps suspended sediments. Since 1978, delta smelt have become increasingly rare in summer and fall

surveys of the San Joaquin region of the San Francisco Bay-Delta. The primary reason appears to be the comparatively high water clarity in the region, although high water temperatures are also likely a contributing factor. Turbid waters are thought to increase foraging efficiency and reduce the risk of predation for delta smelt (USFWS 2015).

Stressor: Channel disturbances
Exposure: Maintenance dredging and other channel disturbances, and disposal of dredged soils.
Response: Re-suspension of contaminants; gill clogging; changes in light transmittance, dissolved oxygen, nutrients, salinity, temperature, and pH; direct injury of delta smelt; and disturbance of delta smelt eggs.
Consequence: Injury, mortality, entrainment, and decreased survival.
Narrative: Channel maintenance dredging occurs regularly in the Bay-Delta and other estuaries that serve as shipping channels. Ongoing maintenance dredging and other channel disturbances potentially degrade spawning habitat and cause entrainment loss of individual fish and eggs; disposal of dredge soils can also create large sediment plumes that expose fish to gill-clogging sediments and possibly to decreased oxygen availability. Dredging can change the light transmittance, dissolved oxygen, nutrients, salinity, temperature, and pH of the water. Dredging will re-suspend contaminants if they are present in the surface sediments. Dredging can result in entrainment, injury, or displacement of delta smelt. Individual delta smelt are likely most vulnerable to entrainment by dredging during spawning and egg incubation, because eggs are deposited and develop on channel bottom substrates (USFWS 2015).

Stressor: Nonnative species
Exposure: Presence of nonnative species.
Response: Increased rates of competition and predation, and food web alteration.
Consequence: Decline in delta smelt abundance.
Narrative: At least three species of nonnative fish with the potential to prey on delta smelt occur in the Delta: striped bass (Morone saxatilis), largemouth bass (Micropterus salmoides), and Mississippi silversides (Menidia beryllina). Striped bass are widely distributed in pelagic areas of the San Francisco Bay-Delta and therefore have wide areas of overlap with delta smelt juveniles and adults. They also tend to aggregate in the vicinity of water diversion structures, where delta smelt are frequently entrained. Thus, striped bass are likely to be the most significant predator of delta smelt. Introduced species have altered the Delta food web and may have played a role in the decline of the delta smelt. The overbite clam is a nonnative species that became abundant in the Delta in the late 1980s and competes with delta smelt for prey. Mississippi silversides are likely both competitors with and predators of delta smelt. Ergeria densa and other nonnative submerged aquatic vegetation can affect delta smelt in direct and indirect ways. Directly, submerged aquatic vegetation can overwhelm littoral habitats where delta smelt may spawn. Indirectly, submerged aquatic vegetation decreases turbidity by trapping sediment suspension, which has contributed to a decrease in both juvenile and adult smelt habitat quality (USFWS 2015).

Stressor: Entrainment
Exposure: Water diversion to agriculture, power plants, and cities.
Response: Entrainment
Consequence: Mortality and reduced fitness.
Narrative: Water is diverted throughout the San Francisco Bay-Delta for use in agriculture, power plants, and cities. Entrainment of delta smelt in water diversion facilities varies among seasons

and years, but can affect the distribution of the population and is considered a threat to delta smelt. Most salvage of juvenile delta smelt occurs from April through July, with a peak in May and June. A study completed in 2008 estimated that from 0 to 62 percent of the larval population and 3 to 50 percent of the adult population is entrained annually by the state and federal export facilities. Entrainment may also affect the distribution of the successfully spawned population. Export of water by the Central Valley Project and the State Water Project likely limits the reproductive success of delta smelt in the San Joaquin River by entraining most larvae during downstream transport from spawning sites to rearing areas. Winter entrainment of delta smelt represents a loss of pre-spawning adults and their reproductive potential. The population-level effects of such losses are unknown. Although there are many factors contributing to the declining trend in delta smelt abundance estimates, entrainment by state and federal water export facilities is considered to be a significant and ongoing threat to the delta smelt. The operation of state and federal export facilities constitute an ongoing threat to delta smelt through direct mortality by entrainment. Entrainment by agricultural diversions is not considered to be a significant threat due to their nearshore location. Entrainment into Pittsburgh power plant has had a significant impact on delta smelt in the past; however, their operations have been modified, and further study is needed to determine the present level of threat to delta smelt (USFWS 2015).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Inadequate protection from federal and state regulations.
Response: Direct mortality, injury, and reductions in habitat quality.
Consequence: Decline in abundance.
Narrative: Delta smelt are listed as endangered under the California Endangered Species Act (CESA). CESA prohibits unpermitted possession, purchase, sale, or take of delta smelt, but does not prohibit "harm," which can include destruction of habitat that kills or injures delta smelt. The Clean Water Act (CWA) has not established a total maximum daily load for ammonia discharge in the Sacramento watershed. The release of ammonia into the estuary is having detrimental effects on the Delta ecosystem and the food chain. The continued decline in delta smelt abundance suggests that existing regulatory mechanisms, as currently implemented, are not adequate to reduce threats to the species (USFWS 2015).

Stressor: Small, isolated populations
Exposure: Small, isolated populations.
Response: Increased risk of inbreeding, loss of genetic diversity, and extinction due to stochastic events.
Consequence: Reduced fitness and increased extinction risk.
Narrative: Delta smelt are relatively concentrated in their rearing habitat during the fall, making them vulnerable to environmental conditions such as drought, contaminant spills, and predation. Small, isolated populations are more likely to lose genetic variability due to genetic drift (random genetic changes over time), and to suffer inbreeding depression (USFWS 2015).

Stressor: Contaminants
Exposure: Contaminants in the Bay-Delta.
Response: Injury or mortality or their prey.
Consequence: Decline in abundance.
Narrative: In 2009, more than 6.8 million kilograms (15 million pounds) of pesticides were applied in the five-county Bay-Delta area, and Bay-Delta waters are listed as impaired for several

legacy and currently used pesticides under the CWA Section 303(d). Pyrethroid pesticides are of particular concern because of their widespread use and their tendency to be genotoxic (DNA damaging) to fishes at low doses. Ammonia loading in the Bay-Delta has increased significantly in the last 25 years. Effects of elevated ammonia levels on fish range from irritation of skin, gills, and eyes to reduced swimming ability and mortality. Delta smelt have shown direct sensitivity to ammonia at the larval and juvenile stages. Ammonia in the form of ammonium has also been shown to reduce primary production by inhibiting nitrate uptake and suppressing spring phytoplankton blooms in Suisun and Grizzly bays. Large blooms of toxic blue-green algae (Microcystis aeruginosa) were first documented in the Bay-Delta during the summer of 1999. Blue-green algae forms large colonies throughout most of the Delta and increasingly down into eastern Suisun Bay. Preliminary evidence indicates that the toxins produced by local blooms are not directly toxic to fishes at current concentrations. However, the copepods that delta smelt eat are particularly susceptible to these toxins. Blue-green algae blooms may also decrease dissolved oxygen to levels lethal to fish (USFWS 2015).

Recovery

Reclassification Criteria:
Reclassification criteria for the species have not been established. However, after review of all available scientific and commercial information, the U.S. Fish and Wildlife Service (USFWS) found that reclassifying the delta smelt from threatened to endangered species was warranted (USFWS 2010), but precluded by other higher priority listing actions. The USFWS will develop a proposed rule to reclassify the species as priorities allow (75 FR 17667).

Recovery Priority Number: 2C

Delisting Criteria:
Restoration of delta smelt should be assessed when the species satisfies distributional and abundance criteria (USFWS 1996). The delta smelt met the abundance and distribution criteria in 2002 based on the 5-year period from 1998 through 2002. However, threats to delta smelt still remain, and sufficient legal mechanisms and interagency agreements are not in place to ensure removal of the threats (USFWS 2004). Since then, the apparent low abundance of delta smelt, in concert with ongoing threats throughout its range, indicates that the delta smelt in now in danger of extinction throughout its range. Based on a review of best scientific and commercial data available, the delta smelt meets the definition of an endangered species under the ESA, and it warrants reclassification from threatened to endangered. However, at this time, the promulgation of a formal rulemaking to reclassify delta smelt is precluded by higher-priority listing actions. The recovery plan is outdated and currently in revision (USFWS 2010).

Distributional Criteria: Four monitoring zones with records of delta smelt were defined to track delta smelt abundance and distribution over time. Each monitoring zone contained multiple FMWT sampling stations. The four zones are: Zone A (North Central Delta), Zone B1 (Sacramento River), Zone B2 (Montezuma Slough), and Zone C (Suisun Bay). Distributional criteria include: (1) catches of delta smelt in all zones 2 of 5 consecutive years; (2) in at least two zones in one of the remaining 3 years, and; (3) in at least one zone for the remaining 2 years (USFWS 1996).

Abundance criteria are: delta smelt numbers or total catch must equal or exceed 239 for 2 out of 5 years and not fall below 84 for more than 2 years in a row (USFWS 1996).

Distributional and abundance criteria can be met in different years. If abundance and distributional criteria are met for a 5-year period, the species will be considered restored (USFWS 1996).

Delta smelt will meet the remaining recovery criteria and be considered for delisting when abundance and distributional criteria are met for a 5-year period that includes 2 successive extreme outflow years, with 1 year dry or critical (USFWS 1996).

Delisting is contingent on the placement of legal mechanisms and interagency agreements to manage the Federal Central Valley Project, State Water Project, and other water users to meet these criteria. Both criteria depend on data collected by California Department of Fish and Wildlife during the FMWT, in September and October (USFWS 1996).

Recovery Actions:

- A recovery plan for the native fishes of the Sacramento-San Joaquin Delta was published in 1996 (USFWS 1996). In 2010, a 5-Year Review was published, which included amended recovery actions; the recovery plan is outdated and currently in revision (USFWS 2010). The following recovery actions are from the 1996 Recovery Plan (USFWS 1996):
- Enhance/restore aquatic and wetland habitat by improving in-Delta and downstream of Delta habitat conditions, reducing entrainment losses to water diversions, reducing the effects of dredging, and reducing the effects of contaminants (USFWS 1996).
- Reduce the effects of harvest (overutilization) by controlling and reducing illegal and commercial harvest (USFWS 1996).
- Reduce the effects of introduced aquatic species by regulating ship ballast water discharges to eliminate or reduce introduction of exotic species, controlling existing harmful introduced species, and halting introductions of new exotic species (USFWS 1996).
- Change and improve enforcement of regulatory mechanisms by setting and enforcing water quality and flow standards to protect native fish, improving implementation and enforcement of Section 404 of CWA and Section 10 of Rivers and Harbors Act of 1898, and developing alternative levee maintenance practices (USFWS 1996).
- Conduct monitoring and research to increase understanding of basic biology and management requirements by 1) monitoring locations and numbers of fish throughout the Delta so that recovery objectives may be implemented and decisions made on successful implementation; 2) developing screening criteria for adults, juveniles, and larvae; 3) conducting toxicology investigations to determine susceptibility of fish to various metals and pesticides; 4) studying effects of introduced species; 5) conducting surveys, monitoring, and studies to better understand delta smelt; and 6) investigating fish use of shallow water habitats, flooded vegetation, and tidal marshes (USFWS 1996).
- Assess effects of Delta native fish recovery management actions (USFWS 1996).
- Increase public awareness of the importance of Delta native fishes by assessing public attitudes on recovering Delta native fishes and developing a public outreach and education program that increases public awareness of positive effects on healthy fisheries and aquatic habitats (USFWS 1996).

- According to the 2010 5-Year Review, the delta smelt recovery plan is outdated and currently in revision. USFWS developed a Spotlight Species 5-Year Action Plan for the delta smelt in 2009. The actions identified in the Plan are intended to ameliorate the effects of limited range and population numbers and prevent extinction of the species. The actions are described in detail in several documents, including the Pelagic Fish Action Plan, the draft Ecosystem Restoration Program Conservation Strategy, the Interagency Ecological Program Pelagic Organism Decline Work Plan, and the USFWS' 2008 Formal Endangered Species Act Consultation on the Proposed Operations of the Central Valley Project and State Water Project. The following recovery actions are from the 2010 5-Year Review (USFWS 2010):
- Establish Delta outflows proportionate to unimpaired flows in the watershed. This action targets facilitation of up- and downstream movement, seasonal expansion of the LSZ, increased winter and spring flows, variability in salinity, and flows to flush contaminants (USFWS 2010).
- Implement water project operations that minimize reverse flows in the Delta when the risk of entrainment into water diversions is high. This action targets increasing the area of suitable spawning habitat and minimizing losses to entrainment (USFWS 2010).
- Work with the University of California, Davis, and the California Department of Water Resources to establish a genetics management plan for delta smelt. This action targets loss of genetic integrity and stochastic demographic extinction (USFWS 2010).
-

Additional Threshold Information:

- Delta smelt are a euryhaline (tolerate a wide range of salinities) species; however, they rarely occur in water with more than 10 to 12 ppt salinity (about one-third seawater). Delta smelt tolerate temperatures from less than 7.5 to greater than 25.4 °C (less than 45.5 to greater than 77.7 °F); however, warmer water temperatures greater than 25 °C (77 °F) restrict their distribution more than colder water temperatures. Currently, delta smelt are subjected to thermally stressful temperatures every summer, and all available regional climate change projections predict that central California will be warmer still in the coming decades (USFWS 2015).
- Delta smelt are a euryhaline (tolerate a wide range of salinities) species; however, they rarely occur in water with more than 10 to 12 ppt salinity (about one-third seawater). Delta smelt tolerate temperatures from less than 7.5 to greater than 25.4 °C (less than 45.5 to greater than 77.7 °F); however, warmer water temperatures greater than 25 °C (77 °F) restrict their distribution more than colder water temperatures. Currently, delta smelt are subjected to thermally stressful temperatures every summer, and all available regional climate change projections predict that central California will be warmer still in the coming decades (USFWS 2015).

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SPECIES ACCOUNT: *Ictalurus pricei* (Yaqui catfish)

Species Taxonomic and Listing Information

Listing Status: Threatened; August 31, 1984 (49 FR 34490).

Physical Description

The Yaqui catfish is a slender, streamlined fish that may grow to more than 60 centimeters (23.6 inches) long and may reach weights exceeding 10 kilograms (22 pounds) in captivity (Miller et al. 2005). The caudal fin is shallowly forked, and the anal fin is broadly rounded. The body is speckled in young; adults are a more solid black on top, and white to grayish beneath (NatureServe 2015; USFWS 1995; USFWS 2013).

Taxonomy

The Yaqui catfish was originally described as Villarius by Rutter (1896). The species name pricei was transferred among a number of genera before being settled on Ictalurus (USFWS 1995). The species is similar to the channel catfish (I. punctatus) in appearance; except the anal fin base is shorter and the distal margin of the anal fin is broadly rounded, with 23 to 25 soft rays (USFWS 2013). The Yaqui catfish has four pair of barbels, 11 pectoral rays, and 16 to 24 gill rakers (Miller et al. 2005).

Historical Range

The historical range of the Yaqui catfish included the uppermost Rio Yaqui system in southeastern Arizona; the basins of the Rio Yaqui and Rio Casas Grandes, Sonora and Chihuahua, Mexico; and also rios Sonora, Mayo, and Fuerte, in northwestern Mexico (NatureServe 2015; USFWS 1995). In the United States, Yaqui catfish are heavily dependent on artesian wells and spring flows on San Bernardino National Wildlife Refuge (SBNWR). Three stream sections—Leslie Creek, West Turkey Creek, and Black Draw—contain Yaqui fishes (NatureServe 2015; USFWS 1995).

Current Range

The Yaqui catfish is extirpated in the Rio Sonora basin and in the Rio Casas Grandes. The Yaqui catfish is restricted to the Rio Yaqui basin of Sonora, Mexico. The Yaqui catfish was also extirpated from the United States; however, it was reintroduced to SBNWR and West Turkey Creek in Cochise County, Arizona in November 1997, from hatchery populations (NatureServe 2015; USFWS 2013).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/31/1984.

Legal Description

On August 31, 1984 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Ictalurus pricei (Yaqui catfish) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Arizona (49 FR 34490-34497).

The critical habitat designation for Ictalurus pricei includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Ictalurus pricei.

Critical Habitat Designation

The critical habitat designation for Ictalurus pricei includes one CHU in Cochise County, Arizona (49 FR 34490-34497).

(1) Arizona, Cochise County. All aquatic habitats of San Bernardino NWR in S1/2 Sec. 11: Sec. 14: S1/2 and NE1/4 Sec. 15: T24S. R30E.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (49 FR 34490-34497):

(1) Known constituent elements include clean unpolluted permanent water in streams with medium current with clear pools in the Rio Yaqui drainage. These waters should be without introduced exotic fishes.

Special Management Considerations or Protections

Section 7(a) of the Act, as amended, requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the Yaqui chub, beautiful shiner and Yaqui catfish, and requires them to ensure that their actions do not result in the destruction or adverse modification of these critical habitats which have been determined by the Secretary. If a “may affect” determination is made, the Federal agency must enter into consultation with the Service. Regulations implementing this interagency cooperation provision are codified at 50 CFR Part 402 and are now under revision (see proposal at 46 FR 29990: June 29, 1983). The only possible activity with Federal involvement that may potentially affect the designated critical habitat is geothermal exploration. This activity is beyond the boundary of the San Bernardino NWR, but could possibly affect underground aquifers supplying surface waters to the critical habitat. Geothermal exploration in the San Bernardino Valley is subject to Federal regulation and licensing by the BLM. It should be emphasized that critical habitat designation may not affect geothermal exploration activities in the vicinity. The designation of critical habitat for these species does not specifically preclude geothermal development in the area. Exploration activities will be allowed to proceed in the vicinity of critical habitat as long as artesian and surface water supplies at San Bernardino NWR are adequately protected. The Act and implementing regulations found at 50 CFR 17.21 and 17.31 set forth a series of general prohibitions and exceptions which apply to all endangered and threatened wildlife. These prohibitions, in part, make it illegal for any person subject to the jurisdiction of the U.S. to take, import or export, ship in interstate commerce in the course of a commercial activity, or sell or offer for sale these species in interstate or foreign commerce. It also would be illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that was illegally taken. Certain exceptions would apply to agents of the Service and State conservation agencies. Regulations codified at 50 CFR 17.22. 17.23, and 17.32 provide for the issuance of permits to carry out otherwise prohibited activities involving endangered and threatened species under certain circumstances. Such permits are available for scientific purposes or to enhance the propagation or survival of the species. In some instances, permits may be issued during a specified period of time to relieve undue economic hardship which would be suffered if such relief were not available. In addition, the two species proposed as threatened, the Yaqui catfish and beautiful shiner, have a special rule which will allow take for educational, scientific, or conservation purposes in accordance with applicable State laws and regulations. Any violation of applicable State law would be a violation of the Endangered Species Act. At present no State laws or regulations are applicable to the Yaqui catfish or beautiful shiner, because neither species is presently found in Arizona. When the reintroduction of these species into Arizona waters occurs, the State will regulate taking in accordance with already existing laws and regulation regarding fishes. This special rule will allow these fishes to be managed as threatened species, thus allowing for more efficient management of the species, and enhancing their conservation.

Life History

Feeding Narrative

Adult: Yaqui catfish are omnivores; they are opportunistic feeders and mostly eat detritus and small invertebrates. Their food source is widely distributed throughout their habitat; although they face competition from feeding with other aquatic animals (mostly fish), the biggest threat to the Yaqui catfish's food source is invasive species (NatureServe 2015; USFWS 1995; USFWS 2013).

Reproduction Narrative

Adult: Little information is known about the Yaqui catfish's breeding and growth. Yaqui catfish have an r-selective reproductive capacity, and males will defend the eggs. Yaqui catfish spawn once a year during a short period of time in May (NatureServe 2015; USFWS 1995; USFWS 2013).

Geographic or Habitat Restraints or Barriers

Adult: Habitat destruction has limited the areas where Yaqui catfish can be found (USFWS 1995).

Spatial Arrangements of the Population

Adult: Clumped according to resources.

Environmental Specificity

Adult: Broad/generalist or community with all key requirements common.

Site Fidelity

Adult: High

Habitat Narrative

Adult: Yaqui catfish live in freshwater, moderate to large streams in areas of slow to swift current over substrates of mud, sand, gravel, rock, and scattered boulders, where vegetation may be sparse except for diatoms and green algae on riffles. Yaqui catfish are generalists in their communities, and their populations are clumped according to resources present in their environments. Yaqui catfish have high site fidelity and live in streams of elevations between 1,219 and 1,425 m (4,000 and 5,000 ft.) in the highlands of the Rio Yaqui basin. Habitat destruction such as water diversion and dam construction have limited the range of the Yaqui catfish (Miller et al. 2005; NatureServe 2015; USFWS 1995; USFWS 2013).

Dispersal/Migration

Motility/Mobility

Adult: Mobile

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low

Immigration/Emigration

Adult: No, but populations are being reestablished in the United States with hatcheries (NatureServe 2015; USFWS 1995).

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: Yaqui catfish are very mobile fish that are nonmigratory and have a low dispersal rate. Captive-hatchery populations have been hatched, and these populations have established in Yaqui catfish habitat (NatureServe 2015; USFWS 1995; USFWS 2013).

Population Information and Trends

Population Trends:

Declining.

Species Trends:

Declining

Population Growth Rate:

Decreasing

Number of Populations:

Yaqui catfish is represented by a limited number of distinct occurrences of fewer than 20 subpopulations (NatureServe 2015).

Population Size:

Unknown (NatureServe 2015)

Adaptability:

Moderate

Population Narrative:

Total adult population size for the Yaqui catfish is unknown, because sightings for the Yaqui catfish are rare. Yaqui catfish are somewhat adaptable, have a low resiliency rate, have low representation, and have low to moderate redundancy due their possibly low population numbers and limited range. Population growth for the Yaqui catfish and species level trends for catfish are both declining (NatureServe 2015; USFWS 1995; USFWS 2013).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Habitat being degraded for water diversion, dam construction etc.
Response: Reduced habitat.
Consequence: Reduction in population numbers.
Narrative: The Yaqui catfish is found in a small range in northwestern Mexico and southwestern Arizona; its habitat has been modified by arroyo cutting, water diversion, dam construction, excessive groundwater pumping, and chemical and sewage pollution. In the United States, Yaqui catfish were extirpated because of groundwater pumping that dried up San Bernardino Creek and decreased spring flow, and because livestock trampling made remaining habitat unsuitable. Geothermal leases pose a potential threat, because they can lower groundwater levels and increase the likelihood of pollution (NatureServe 2015; USFWS 1995).

Stressor: Nonnative fish
Exposure: Nonnative fish introduced into Yaqui habitat.
Response: Illness or mortality.
Consequence: Reduction in population number. More vulnerable to disease. Out-competed by other fish.
Narrative: Threats from nonnative species to the Yaqui catfish have increased in recent years. Most, if not all, drainages in Yaqui catfish habitat are currently inhabited by nonnative fish. Nonnative blue and channel catfish, the nonnative black bullhead, and the flathead catfish have all been found in Yaqui catfish habitat. Hybridization of the Yaqui catfish with the channel catfish now appears throughout the habitat. In addition, nonnative fish also compete with or out-compete with the Yaqui catfish for food and resources, which puts hardships on the Yaqui catfish populations (NatureServe 2015; USFWS 1995).

Stressor: Species protection in Mexico
Exposure: No protective measures have been put in place for Yaqui catfish in Mexico.
Response: See narrative.
Consequence: See narrative.
Narrative: Most of the Yaqui catfish population occur in Mexico, where there are few to no protection measures in place. The lack of protection places a hardship on the Yaqui catfish population, because they are potentially exposed to all threats, with little hope for improvement (NatureServe 2015; USFWS 1995; USFWS 2013).

Recovery

Reclassification Criteria:
None
None
None

None
None
None

Delisting Criteria:
All the following conditions must be met in currently occupied habitat for a period of 10 years before consideration of delisting for the Yaqui catfish:

Secure and protect San Bernardino Valley aquifers so that all artesian-well and other flows from subsurface sources are perennial. Secure and protect Leslie Creek, Black Draw, and Mimbres River, New Mexico, watersheds to ensure adequate, perennial flow.

Eradicate all nonindigenous fish species and other undesirable organisms such as bullfrogs from critical habitat. from critical habitat.

Protect critical habitat and other habitats where species of concern occur or are reestablished from human disturbances, including excessive grazing, irrigated agriculture, mining, introductions of nonindigenous species, and water diversion or removal.

San Bernardino/Leslie Canyon NWR and associated waters, because of their physical size, can only act as a genetic and population refugium. Delisting can occur when recovery in the form of protection of wild populations from threats of hybridization, negative interactions with nonindigenous species, or other negative impacts is assured in Mexico, and Mexican populations are therefore secure and self-sustaining.

Recovery Actions:
- Cooperate on recovery with Mexico.
- Manage existing habitats and populations.
- Determine biological requirements of listed species.
- Protect historic habitats of fishes of concern in the United States.
- Assess habitats for reintroduction, and reestablish the species of concern in appropriate habitats in historic ranges.
- Develop information and education programs for all species, their habitats, and the ecosystem(s) on which they depend.
- Recommend uplisting to Endangered (USFWS, 2019).
- RECOMMENDATIONS FOR FUTURE ACTIONS Because 98% of the geographic range of this species exists in the Republic of Mexico, recovery of the Yaqui catfish must occur in that country for the fish to avoid extinction. A first step toward potential recovery would be to survey potential wetland habitat in Mexico to determine presence/absence of Yaqui catfish, and plans are underway to collect water samples through monitoring efforts in Sonora, Mexico. These water samples would then be analyzed in the U.S. for eDNA of Yaqui catfish. Once areas having extant populations of Yaqui catfish are identified, planning could be accomplished to protect those occupied habitats as natural refugia for Yaqui catfish and/or to collect a subsample of the catfish population in those habitats and propagate them in suitable hatcheries in Mexico and the U.S. to produce stock for potential reintroduction efforts in protected waters. Any reintroduction program will require finding and collecting genetically heterozygous Yaqui catfish for potential propagation in a hatchery environment;

developing consistent captive propagation techniques and a genetic management plan; identifying secure, suitable wetlands in both Mexico and the U.S.; establishing Yaqui catfish into those wetlands; ultimately documenting sustaining self-perpetuating populations; and abolishing the captive propagation and stocking of non-native channel catfish and flathead catfish in Sonora, Mexico. While these concepts seem sound, implementation is limited by funding availability, permitting obstacles, and by access limitations into the lotic systems in rural Mexico by researchers. Many of the areas containing potential catfish habitat are currently (2019) under the control of drug cartels who threaten the safety of researchers in Mexico (USFWS, 2019).

Additional Threshold Information:

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SPECIES ACCOUNT: *Lepidomeda albivallis* (White River spinedace)

Species Taxonomic and Listing Information

Listing Status: Endangered; September 12, 1985.

Physical Description

White River spinedace are the most brightly colored of the four species of Lepidomeda. Their dorsal and caudal fins are pale olive-brown to pinkish brown, with the rays often deep-olive and with the rather clear interradial membranes faintly flushed with rosy color; pectorals are yellowish with orange-red axils; and the anal and pelvic fins are bright orange-red. In females, the coloration is similar but less intense. The White River spinedace is a relatively large species of Lepidomeda, and often attains a length of 10 to 13 centimeters (4 to 5 inches). It has a moderately oblique mouth, and a dorsal fin of moderate height (50 FR 37194; USFWS 1994).

Taxonomy

The White River spinedace is a member of the Plagopterini tribe of cyprinid fishes that include the monotypic genera Meda and Plagopterus, and the polytypic genus Lepidomeda. Members of the tribe are distinguished from other cyprinids by: 1) the spine-like character of the pelvic and pectoral fin rays, and the two anterior dorsal fin rays; 2) a membranous connection between the innermost ray of the pelvic fins and the belly; 3) bright silver coloration; and 4) the absence or diminutive development of body scales. It can be distinguished from other species by its possession of a pharyngeal tooth formula of 5-4 in the main row (USFWS 1994).

Historical Range

White River spinedace were historically found throughout the upper White River drainage in seven spring systems. When the type specimen was collected in 1938, the species was known from the White River below the mouth of Ellison Creek, Preston Big Spring, Nicholas Spring, Lund Spring, Arnoldson Spring, Flag Springs (comprising North, Middle, and South Flag Springs, which interconnect and flow into Sunnyside Creek), and the confluence of Nicholas and Preston Big Springs.

Current Range

At the time of listing in 1985, the species' distribution was limited to Lund and Flag Springs. By 1991, spinedace remained only in a single 70-meter (m) (229.7-foot [ft.]) stream reach at North Flag Spring. In 1995, 20 adult spinedace were moved into the North Flag Spring outflow. Currently, spinedace are able to freely migrate between each spring and their associated outflows and downstream into Sunnyside Creek, inhabiting approximately 2.5 kilometers (1.55 miles) of habitat at Kirch Wildlife Management Area (USFWS 2010).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/12/1985.

Legal Description

On September 12, 1985, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Lepidomeda albivallis (White River spinedace) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two critical habitat units (CHUs) in Nevada (50 FR 37194-37198).
The critical habitat designation for Lepidomeda albivallis includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Lepidomeda albivallis.

Critical Habitat Designation

The critical habitat designation for Lepidomeda albivallis includes two CHUs in Nye and White Pine Counties, Nevada (50 FR 37194-37198).

Unit 1—Nevada, White Pine County. Each of the following springs and outflows plus surrounding land areas for a distance of 5O feet from these springs and outflows. Preston Big Spring and associated outflows within T12N. R61E. NE ¼ Sec. 2. Lund Spring and associated outflows within T11N, R62E, NE ¼ of NE ¼ of Sec. 4: T12N. R62E. S ½ of SE ¼ Sec. 33.

Unit 2—Nevada. Nye County. Flag Springs and associated outflows plus surrounding land areas for a distance of 50 feet from the springs and outflows within the following areas: T7N. R62E. E ½ of NE ¼ Sec. 32. SW ¼ of NW ¼ Sec. 33.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs for Lepidomeda albivallis in Nevada are not specified but are assumed to be the following (50 FR 37194-37198):

(1) Known constituent elements for all areas of critical habitat include consistently high quality and quantity of cool springs and their outflows, and surrounding land area that provide vegetation for cover and habitat for insects and other invertebrates on which the species feeds.

Life History

Feeding Narrative

Adult: White River spinedace consume a variety of food items, which indicates that the species is a habitat and dietary generalist (Scoppettone et al. 2004). Analysis of stomach contents from White River spinedace that were collected in the 1960’s and observations of actively feeding spinedace suggest that they feed on drifting invertebrates and plant material (Scoppettone et al. 2004). No life history, food preference, or habitat requirement studies have been completed for the White River spinedace. (USFWS, 2021)

Reproduction Narrative

Adult: White River spinedace spawning has never been observed, and spawning habitat requirements are unknown. It is possible that the species spawns during the summer (USFWS 1994).

Geographic or Habitat Restraints or Barriers

Adult: Some springs that historically supported seasonal use by White River spinedace are currently hydrologically disconnected, creating habitat restraints to once-occupied areas of the species' distribution.

Spatial Arrangements of the Population

Adult: White River spinedace seem to prefer shallow areas that are 0.5 to 1.5 m (1.6 to 4.9 ft.) deep (NatureServe 2015).

Environmental Specificity

Adult: Narrow/specialist

Tolerance Ranges/Thresholds

Adult: Moderate

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: Dependent on aquatic vegetation for habitat of aquatic invertebrates.

Habitat Narrative

Adult: White River spinedace prefer spring habitats with clear, cool water and source pools with emergent aquatic vegetation (USFWS 1994). They also prefer shallow areas that are 0.5 to 1.5 m (1.6 to 4.9 ft.) deep (NatureServe 2015). Their environmental specificity is narrow and they have a moderate tolerance threshold. Site fidelity for the White River spinedace is high, and the ecological integrity of the community is low. Some springs that historically supported seasonal use by White River spinedace are currently hydrologically disconnected, creating habitat restraints to once-occupied areas of the species' distribution (USFWS 1994).

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: Available suitable habitat for the White River spinedace has been reduced by channeling, piping, and diversion of spring flows. To facilitate habitat continuity, this species requires cool, flowing springs that are hydrologically connected. Artificial fish barriers have been added to limit migration of nonnative fish. The result is poor habitat connectivity and reduced dispersal

(USFWS 2010).

Population Information and Trends

Population Trends:

The populations have fluctuated within and among seasons, which could be caused by seasonal population variations (reproduction, etc.) and other natural factors.

Species Trends:

Same as population level trends.

Population Growth Rate:

Has increased over the survey period (1995 through 2008) from fewer than 25 to between 1,000 and 2,000 individuals (USFWS 2010).

Number of Populations:

Currently there is one successfully reproducing population of spinedace, found in Flag Springs and upper Sunnyside Creek (USFWS 2010).

Population Size:

The abundance of spinedace has increased substantially in Flag Springs and Sunnyside Creek, and 2,000 or more individuals are typically present in surveys (USFWS 2010).

Adaptability:

Low

Population Narrative:

At the time of listing in 1985, there were fewer than 100 known White River spinedace. The abundance of spinedace has increased substantially in Flag Springs and Sunnyside Creek, and is currently somewhere between 1,000 and 2,000 individuals. Although the spinedace have increased their numbers and distribution in historical habitat at Flag Springs and upper Sunnyside Creek, their overall limited distribution and relatively low population size still leave the species highly susceptible to extinction (USFWS 2010).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Channelization of spring habitats and diversion of water.
Response: Significant stress on individuals/reduced population size.
Consequence: Decreased reproductive success.
Narrative: White River spinedace habitats have been altered since the mid-1800s, when the first settlers began diverting water from streams and spring outflows for agriculture and ranching purposes. Six of the seven historical habitats for spinedace have been dramatically altered and are currently unrestored and privately owned.

Stressor: Competition
Exposure: Competition from nonnative fish species is an ongoing potential threat but is not currently a threat.

Response: Increased competition for available resources.
Consequence: Less food and habitat for the White River spinedace.
Narrative: Nonnative fish species have been implicated in the decline and listing of spinedace due to predation and/or competition for available resources. They are currently excluded from designated critical habitat, but the threat of deliberate or inadvertent introduction of such species will always be present.

Stressor: Predation
Exposure: Predation by double crested cormorants (Phalacrocorax aurilus).
Response: White River spinedace is more vulnerable to predation.
Consequence: Reduced population size of White River spinedace.
Narrative: The increasing population of cormorants across western North America has led to increasing numbers of cormorants using reservoirs and streams in eastern Nevada.

Recovery

Reclassification Criteria:
A self-sustaining population exists in each of the three designated critical habitats for at least 5 consecutive years (USFWS 2010).

Each critical habitat is secure from all known threats (USFWS 2010).

All native fish are present in Flag Spring, Preston Big Spring, and Lund Spring that were present historically (USFWS 2010).

Delisting Criteria:
Need to develop delisting criteria

Recovery Actions:

- Prevent migration of nonnative fishes into the Flag Springs System.
- Develop nonnative eradication plan.
- Implement nonnative eradication plan.
- Prepare emergency refugia plan.
- Implement emergency refugia plan.
- Determine life history and habitat requirements.
- Determine species interactions.
- Conduct population viability analysis.
- Develop habitat management plan.
- Implement habitat management plan.
- Develop and implement population monitoring plan.
- Protect habitat at Preston Big Spring and Lund Spring.
- Develop and implement habitat rehabilitation plans.
- Develop and implement reintroduction plan.
- Develop and implement population monitoring plan.
- Amended recovery criteria 1. Self-sustaining populations of White River spinedace exist in at least one critical habitat unit and two additional locations. Justification: This adds an additional redundant population to what is presented in the amended downlisting criteria,

which should provide a sufficient buffer should one or more populations be affected by a catastrophic event. 2. White River spinedace show representation, resiliency, and redundancy. a. Resiliency - Ensure that each White River spinedace population contains an adequate number of individuals that are distributed throughout sufficient habitat to withstand stochastic, population-level events. Minimum viable population size will be determined once we have more information on the species. b. Redundancy - Guarantee that an adequate number and distribution of White River spinedace populations occur to withstand catastrophic events. Catastrophic events for the species include rapid expansion of nonnatives such as predatory fish species, or reduction in spring flow from drought or groundwater pumping. At least 3 selfsustaining populations exist (self-sustaining defined as having 3 or more age-classes present, as well as a stable population with no downward trend and documented reproduction and recruitment for at least 5 years). c. Representation - Conserve White River spinedace by ensuring it is present within a variety of ecological (e.g., pool and stream habitat) and geographic settings in order to maintain genetic diversity and adaptive capacity over time. At least three selfsustaining populations exist across distinct geographic and ecological settings (e.g., stream, pond). Justification: Currently, Service policy is to utilize a Species Status Assessment to evaluate species status for the purposes of listing under the Act. The SSA process evaluates species status based on representation, resiliency, and redundancy. This criterion incorporates the SSA process into the recovery plan (Service 2016). 3. All impacts to the species and its habitat have been reduced to the point that the species is unlikely to become endangered within the foreseeable future throughout all or a significant portion of its range. Justification: This added criterion further builds on the requirement to alleviate threats for downlisting based on the statutory definitions of threatened and endangered in the Act (USFWS, 2019).

- Continue collaborative partnership development with the Preston and Lund Irrigation Districts, as well as with other willing private and public landowners, to further the establishment of spinedace at known historical habitats.
- Conduct further studies of spinedace habitat requirements and spawning habitat needs at Flag Springs.
- Investigate additional springs and streams to determine the viability of spinedace reintroduction outside of the designated critical habitats.
- Collect and analyze spring flow and groundwater monitoring data to identify and determine effects of groundwater development projects on critical habitats and other potential recovery habitats.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: ⍰ Establish a second population. Prior to establishment, consideration should be given to identifying potential locations, meeting regulatory requirements, and determining appropriate stock of fish (e.g., wild, captive propagation). ⍰ Develop a vegetation management plan, potentially including a rotational burn schedule. Focus of the vegetation management plan should be on managing nonnative or invasive vegetation as well as maintaining open water habitat. ⍰ Determine if the declining trend data from snorkel surveys is a result of vegetation overgrowth or an actual decrease in population size. This could be done by surveying the population using a different method and comparing results to snorkel data. (USFWS, 2021)

Additional Threshold Information:

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References

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USFWS. 2021. White River spinedace (Lepidomeda albivallis) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southern Nevada Fish and Wildlife Office Las Vegas, Nevada. 8 pp.

SPECIES ACCOUNT: *Lepidomeda mollispinis pratensis* (Big Spring spinedace)

Species Taxonomic and Listing Information

Listing Status: Threatened; March 28, 1985.

Physical Description

Big Spring spinedace are bright silver in color, with some individuals having yellow to orange at the axils of paired fins, base of the anal fin, upper edge of the shoulder girdle, vertical arm of the preopercular bone, and above the mouth. Specimens collected range from 48 to 93 millimeters (1.9 to 3.7 inches) in total length. The Big Spring spinedace and other members of the tribe Plagopterini are characterized by having two anterior spine-like dorsal fin rays; and branched pelvic rays that are thickened, consolidated, vitreous, and spine-like on the basal half to three-fourths of their length. The Plagopterini are further characterized by having pelvic fins attached to the belly by a membrane along the osseous part of the innermost ray. Characteristics of the genus Lepidomeda include a body completely covered with scales; a second dorsal spine stronger and longer than the first; a rounded head and belly; and a head about or more than two-thirds as deep as long (NatureServe 2015; USFWS 1993).

Taxonomy

The Big Spring spinedace is part of the Plagopterini tribe of cyprinid fishes, which includes the monotypic genera Meda (spinedace) and Plagopterus (woundfin); and the polytypic genus Lepidomeda (spinedace). Plagopterin fishes are among the few North American cyprinids that are not known to hybridize with other genera. Spinedace have weakly developed dorsal and pectoral fin spines compared to the strongly developed spines of spinedace and woundfin. Spinedace also possess diminutive scales, whereas spinedace and woundfin are scaleless. Big Spring spinedace is differentiated from Virgin River spinedace (Lepidomeda mollispinis mollispinis) by a higher, more pointed dorsal fin; longer pelvic fins; and a smaller, more oblique mouth (NatureServe 2015; USFWS 1993).

Historical Range

Big Spring spinedace were first collected from the outflow stream of Panaca Spring and its adjacent wet meadow near Panaca, Nevada. The species was discovered in Condor Canyon of Meadow Valley Wash, several kilometers upstream from the type locality.

Current Range

Currently, the Big Spring spinedace occupies an 8-kilometer (km) (4.97-mile [mi.]) section of Meadow Valley Wash in Condor Canyon, Nevada (50 FR 12298; NatureServe 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 3/28/1985.

Legal Description

On March 28, 1985, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Lepidomeda mollispinis pratensis (Big Spring spinedace) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Nevada (50 FR 12298-12302).
The critical habitat designation for Lepidomeda mollispinis pratensis includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Lepidomeda mollispinis pratensis.

Critical Habitat Designation

The critical habitat designation for Lepidomeda mollispinis pratensis includes one CHU in Lincoln County, Nevada (50 FR 12298-12302).

Unit 1—Nevada, Condor Canyon, Lincoln County. Four stream miles of Meadow Valley Wash and 50 feet on either side of the stream as it flows through the following sections: T. 1 S., R. 68 E., Sections 13, 23, 24, 26, 27, and 28.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs for Lepidomeda mollispinis pratensis in Nevada are not specified but are assumed to be the following (50 FR 12298-12302):

(1) Known constituent elements include clean permanent flowing spring-fed stream with deep pool areas and shallow marshy areas along the shore and the absence of exotic fishes.

Life History

Feeding Narrative

Adult: Individuals position themselves behind stream cover and have been observed to dart into the current to inspect or ingest potential food items and quickly return to their position. They are thought to be opportunistic feeders that will consume insect larvae, algae, and other plant material. They require clean, permanent flowing spring-fed streams with deep pool areas and shallow, marshy areas along the shore; as well as instream cover, particularly watercress along the stream margin. Nonnative fish, including rainbow trout, largemouth bass, and white crappie, have been reported in the Big Spring spinedace habitat, and could compete for food and space (NatureServe 2015; USFWS 1993).

Reproduction Narrative

Adult: Big Spring spinedace spawning behavior has never been observed, and spawning habitat requirements are unknown (USFWS 1993).

Geographic or Habitat Restraints or Barriers

Adult: No

Spatial Arrangements of the Population

Adult: Adults inhabit runs and pools with a depth of at least 0.25 meters (m) (0.82 foot [ft.]) in Meadow Valley Wash through Condor Canyon (NatureServe 2015).

Environmental Specificity

Adult: Narrow

Tolerance Ranges/Thresholds

Adult: Narrow

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: None

Habitat Narrative

Adult: Big Spring spinedace require fresh water with dense riparian vegetation; and sections of dense aquatic vegetation, primarily watercress (Nasturtium officinale). This species requires clean, permanent flowing spring-fed stream with deep pool areas and shallow marshy areas along the shore, and the absence of exotic fish. Adults inhabit runs and pools with a depth of at least 0.25 m (0.82 ft.) in Meadow Valley Wash through Condor Canyon (NatureServe 2015). Environmental specificity is narrow, as is the tolerance threshold of the species. Site fidelity is high and the ecological integrity of the community is low.

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low

Immigration/Emigration

Adult: No

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: Big Spring spinedace are endemic to a very narrow habitat range. The species is nonmigratory, with low motility and low dispersal potential, and it does not immigrate/emigrate (USFWS 1993).

Population Information and Trends

Population Trends:

Abundant within Condor Canyon (USFWS 1993).

Species Trends:

Abundant within Condor Canyon (USFWS 1993).

Number of Populations:

There is one known population in Condor Canyon.

Adaptability:

Low

Population Narrative:

As of the early 1990s, the Big Spring spinedace occupied 8 km (4.97 mi.) of habitat in Condor Canyon within Meadow Valley Wash, Lincoln County, Nevada. This population was considered abundant in the early 1990s. There is no current information available for this species (NatureServe 2015; USFWS 1993).

Threats and Stressors

Stressor: Destruction of habitat
Exposure: Dewatering, drought, erosion, and pollution from excess livestock grazing.
Response: Increased stress on the population.
Consequence: Dewatering of the channel and drought both decrease habitat quality. Erosion and pollution from grazing may increase siltation, thereby decreasing habitat for spawning and allowing emergent vegetation to establish, which alters the habitat.
Narrative: Habitat destruction is a threat to the current population of Big Spring spinedace. This species is vulnerable to a number of types of habitat destruction—such as increased erosion, dewatering, and erosion and pollution from livestock grazing—which may directly deplete the population or destroy the habitat (NatureServe 2015; USFWS 2014).

Stressor: Occurrence of nonnative fish
Exposure: There are several species of nonnative fish present in Condor Canyon, including rainbow trout, largemouth bass, and white crappie.
Response: Invasive fish species may prey on the Big Spring spinedace and may compete for available resources.
Consequence: Increased stress on the Big Spring spinedace and a potential decrease in available resources.
Narrative: There are several nonnative fish species in Condor Canyon. These species could prey on Big Spring spinedace, as well as compete with them for food and space (NatureServe 2015).

Stressor: Human activities
Exposure: Public use of Condor Canyon is increasing. Threats include stream degradation from off-road vehicles, garbage dumping, and wood cutting.
Response: Decrease in habitat quality and a potential risk of additional nonnative species.
Consequence: May cause additional stress on the Big Spring spinedace due to habitat destruction and potential nonnative species introductions.
Narrative: Human activity in the Condor Canyon area has increased in recent years. Human use has included off-road vehicles, garbage dumping, and wood cutting. These impacts pose the threat of habitat degradation as increasing the risk of nonnative species introductions (USFWS

2014).

Stressor: Grazing (USFWS, 2021)
Exposure:
Response:
Consequence:
Narrative: Streambank erosion resulting from cattle grazing makes effective control of instream vegetation more difficult. Cattle flatten and widen streams, slowing the flow, increasing sediment accumulation and thus improving the habitat for crayfish and aquatic vegetation. They also transport seeds and produce nitrogenous waste, which spurs plant growth in and around the stream. (USFWS, 2021)

Recovery

Delisting Criteria:
May be proposed for delisting when a self-sustaining population exists in Meadow Valley Wash at Condor Canyon for at least 5 consecutive years, and its habitat is secured from all known threats.

Recovery Actions:
- Secure Big Spring spinedace habitat in Condor Canyon by obtaining conservation agreements with private landowners, and instream flow water rights. agreements with private landowners and instream flow water rights.
- Monitor Big Spring spinedace population in Condor Canyon.
- Establish Big Spring spinedace refugium population.
- Enhance Big Spring spinedace population in Condor Canyon.
- Enhance Big Spring spinedace habitat in Condor Canyon.
- Implement public outreach program.
-

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS Over the next 5 years, focus should be on collecting population trend information, planning for the establishment of a secondary population, assessing effects from nonnative aquatic species (e.g. signal crayfish, rainbow trout), and improving habitat below Delmue Falls within Condor Canyon. Population monitoring should continue to occur at established sites. These monitoring efforts should be implemented by NDOW with assistance from the Service and others. If funding allows, conducting a more robust sampling, such as those developed by USGS may be worth considering (Jezorek et al. 2011). The instability and potential for catastrophic loss of habitat warrants the establishment of a second population. Since Big Spring spinedace are a federally listed species, there are regulatory as well as biological considerations that must be met before establishing a population. To aid in the selection of a transplant site, we should identify and collect baseline information that can be compared to occupied habitat in Condor Canyon. Specifically, we should compare habitat characteristics at potential sites with those of the habitat above Delmue Falls. As for regulatory considerations, a decision should be made whether to pursue a safe harbor agreement or try to identify areas for the establishment of a 10j population (e.g., non-essential, experimental). Additionally, efforts should be made to identify research needs for Big Spring spinedace. This information can be used to guide the establishment of successful

refugia for the species. Potential research needs may include: 1) life history; 2) food web dynamics; and 3) predator-prey relationships between Big Spring spinedace and nonnative species (i.e., signal crayfish, rainbow trout). (USFWS, 2021)

Additional Threshold Information:

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SPECIES ACCOUNT: *Lepidomeda vittata* (Little Colorado spinedace)

Species Taxonomic and Listing Information

Listing Status: Threatened; September 16, 1987; Southwest Region (R2)

Physical Description

Mouth moderately oblique; second “spine”of dorsal fin strong; Dorsal fin moderatelyhigh, and acute, its depressed length 2.0 to2.3 in predorsal length; anal fin-rays eight(rarely nine). The species is generally less than100 mm in total length (Miller 1963). Life colors described by Miller (1963)were as follows: “. . . nearly vertical darklines (that extends dorsally from themidside) shine like polished silver and theventer is white. The upper sides areolivaceous, and the back is olivaceous,bluish or lead grey. Except for pigmentationalong the fin rays and on the interradialmembranes near the bases of the fins,both paired and unpaired fins are largelyclear. Parts ofthe belly are watery-yellow; fins otherwiseclear. Scales show light bluish to greenishbrassreflections.

Taxonomy

The species was described by Cope (1874) from specimens collected during 1871-1874 by the Wheeler expedition (Wheeler 1889). The spinedace is a member of the tribe Plagopterini and is represented by three other species (one extinct) as well as by two monotypic genera (Meda and Plagopterus). All members of the Plagopterini are already listed as either threatened or endangered or are in the process ofbeing listed. The other species of spinedace occur in extreme northwest Arizona (L. mollispinis) and in Nevada and Utah (L. albivallis and L. altivelis, Miller and Hubbs 1960; Minckley 1973; LaRivers 1962).

Historical Range

This species formerly occurred throughout the upper sections of the Little Colorado River system in eastern Arizona, (Minckley 1973, Lee et al. 1980, Page and Burr 2011).

Current Range

Currently the range of the species is confined to disjunct locations within the East Clear Creek Watershed, Chevelon Creek, the upper Little Colorado River (including Nutrioso and Rudd Creeks), and Silver Creek (USFWS 2008). Recent surveys did not locate this species in Silver Creek, and very few were found in Nutrioso and Rudd creeks; this species is considered rare in the East Clear Creek watershed, Chevelon Creek, and the mainstem Little Colorado River (USFWS, Arizona Ecological Services Field Office; USFWS 2008).

Distinct Population Segments Defined

No.

Critical Habitat Designated

Yes; 1/1/1987.

Legal Description

On September 16, 1987, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Lepidomeda vittata (Little Colorado spinedace) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes three critical habitat units (CHUs) in

Arizona (52 FR 35034-35041).
The critical habitat designation for Lepidomeda vittata includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Lepidomeda vittata.

Critical Habitat Designation

The critical habitat designation for Lepidomeda vittata includes three CHUs in Coconino, Navajo and Apache Counties, Arizona (52 FR 35034-35041).

Unit 1—Arizona, Coconino County. East Clear Creek: approximately 18 miles of stream extending from the confluence with Leonard Canyon (NE ¼ Sec. 11 T14N R12E) upstream to the Blue Ridge Reservoir dam (SE ¼ Sec. 33 T14N R11E), and approximately 13 miles of stream extending from the upper end of Blue Ridge Reservoir (east boundary SE ¼ Sec. 36 T14N R10E) upstream to Potato Lake (NE ¼ Sec. 1 T12N R9E).

Unit 2—Arizona, Navajo County. Chevelon Creek; approximately 8 miles of stream extending from the confluence with the Little Colorado River (NW ¼ Sec. 23 T18N R17E) upstream to Bell Cow Canyon (SE ¼ of the SW ¼ Sec. 11 T17N R17E)

Unit 3—Arizona, Apache County. Nutrioso Creek; approximately 5 miles of stream extending from the Apache-Sitgreaves National Forest boundary (north boundary Sec. 5 T8N R30E) upstream to the Nelson Reservoir dam [NE ¼ Sec. 29 T8N R30E).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs for Lepidomeda vittata in Nevada are not specified but are assumed to be the following (52 FR 35034-35041):

(1) Constituent elements, for all areas of critical habitat, include clean, permanent flowing water, with pools and a fine gravel or silt-mud substrate.

Life History

Feeding Narrative

Larvae: same as adult

Juvenile: same as adult

Adult: Adult, juvenile and larval Little Colorado spinedace are opportunistic omnivores that consume vegetation, insects, and crustaceans (Minckley and Carufel 1967 p. 299, Runck and Blinn 1993 pp. 157-159, USFWS 2008 p. 4). Shifts in the spinedace diet may reflect intra-stream distribution of predator and prey, as well as prey availability (Runck and Blinn 1993 p. 158). Filamentous green algae, vascular plants, and other woody debris are all consumed by the species during certain times of the year (Minckley and Carufel 1967 p. 299, Runck and Blinn 1993 pp. 157-158). The largest percentage of their diet consists of a wide range of terrestrial and aquatic insects (Runck and Blinn 1993 p. 157, USFWS 2008 p. 4). Runck and Blinn (1993 p.

157) determined that insects made up 55% of the species diet, of which chironomid larvae and adult dipterans were the most common aquatic and terrestrial prey species in their diet. Other insect prey include, but are limited to, mayflies, stoneflies, caddisflies, dragonflies, damselflies, riffle beetles, grasshoppers, beetles, ants, and wasps (Minckley and Carufel 1967 p. 299, Runck and Blinn 1993 p. 158). Prey species are dictated by the gape limitation of each fish with smaller fish consuming smaller prey species. Shifts in the spinedace diet may reflect intra-stream distribution of predator and prey, as well as prey availability (Runck and Blinn 1993 p. 158). Vegetation becomes more important as a food resource during the summer as the abundance of benthic aquatic insects decreases and the abundance of aquatic vegetation increases (Runck and Blinn 1993 p. 157). Crustaceans become more important during summer months as the abundance of aquatic insects decreases (Runck and Blinn 1993 pp. 157-158).

Reproduction Narrative

Egg: Eggs are randomly deposited on aquatic vegetation (USFWS 1998 p. 3).

Adult: Most spawning takes place in early summer, but it continues sporadically through early fall. Females carry from 650-5000 eggs depending on their size (Lee et al. 1980). Preliminary data indicate that spinedace are 6-8 mmin total length when they hatch and reach 25 mmin one month. After 10 weeks fish are 50-60 mm, reaching 75-80 mm by the end of the first year. Collection of the original transplants placed in the Arboretum pond indicates they live at least 3 years (Dean Blinn, pers. comm.).

Geographic or Habitat Restraints or Barriers

Adult: Dams lacking a suitable fishway, high waterfall, and upland habitat. An impoundment may constitute a barrier. Presence of nonnative fishes, such as the red shiner.

Environmental Specificity

Adult: See key resources

Tolerance Ranges/Thresholds

Adult: See key resources

Habitat Narrative

Egg: Eggs are randomly deposited on aquatic vegetation (USFWS 1998 p. 3). Eggs are deposited over cobble and gravel substrates (USFWS 2008 p. 7).

Adult: The little Colorado spinedace inhabits small to medium streams charecterized by clear, flowing pools with slow to moderate currents (Minckley and Carufel 1967 p. 292, USFWS 2008 p. 7). Natural flow regimes and periodic flooding maintain essential pool habitat for the species through the deposition and removal of sediment (USFWS 1998 p. 5). Reduced flows can also result in the reduction or elimination of habitat and can also result in failure to reconnect isolated inhabited pools that would typically reconnect as water flows increase. Water withdrawals and dams are a major threat to the existence of the species. The species typically resides in pools with slow to moderate current and is adjacent to riffles (USFWS 1998 p. 3). Spring fed areas within the stream are important in providing the species perennial habitat that the species may utilizes during normal low flow or drought (USFWS 2008 p.). During high flows or flooding, spinedace will move lateral to the current finding refuge in slower water along the stream margin (Minckley and Carufel 1967 p. 293). The species occupies pools of moderate depths during normal periods, but will seek out deeper residual pools during periods of normal low flow or drought (Minckley and Carufel 1967 p. 292, USFWS 2008 p. 8). It is usually is found at depths of 1-2 meters (Miller 1963 p. 3, USFWS 1998 p. 3). While it typically avoids the deeper water, the species will retreat to the deepest water available when threatened or to avoid temperature extremes (Minckley and Carufel 1967 p. 293). Spine dace also avoid shallow open areas, presumably to avoid predators (Minckley and Carufel 1967 p. 293). While the species selects pools with partial cover (i.e., overhanging streamside vegetation, undercut banks and large rocks), completely shaded pools are not suitable for the species, presumably due to lower water temperatures (Miller 1963 p. 4). The little Colorado spinedace occupy habitats with temperatures that range between 14.4-25.6°C (USFWS 2008 p. 8). During seasonal temperature extremes, the spinedace will occupy water found in near the bottom of deeper pools or in the constant temperatures found in springs (Minckley and Carufel 1967 p. 293).

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant

Dispersal

Adult: Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats.

Dispersal/Migration Narrative

Adult: Limited data indicate limited movements, but further study is needed (Sweetser et al. (2002). Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats.

Population Information and Trends

Population Trends:

Declining to relatively stable

Species Trends:

50 percent declining to relatively stable

Population Growth Rate:

Unknown

Number of Populations:

4 (USFWS, 2023)

Population Size:

Unknow, but less that 10,000 individuals

Minimum Viable Population Size:

Unknown

Resistance to Disease:
Unknown

Adaptability:
Unknown

Additional Population-level Information:
Genetic data indicate the importance of maintaining all remaining populations (Tibbets et al. 2001).

Population Narrative:
The spinedace currently occupies portions of the streams it is known from historically within the East Clear Creek, Chevelon, Silver Creek, and upper LCR watersheds. However, populations are generally small and the true population size for any occupied stream is unknown due to the yearly fluctuations and difficulty in locating fish. Populations seem to appear and disappear over short time frames and this has made specific determinations on status and exact location of populations difficult. This tendency has been observed by both researchers and land managers (Miller 1963, Minckley 1965, Minckley 1973) and increases uncertainty over the actual status of any specific population. This ephemeral nature makes management of the species difficult because responses ofthe population to changes within the watershed cannot be measured with certainty. In addition, small clusters of spinedace confined to limited habitat areas may be more vulnerable to extinction from random environmental, genetic, and demographic events (Schonewald-Cox 1983), and re-establishment of a local population would require immigration from another local area under proper environmental conditions. In 2008, the USFWS were able to locate spinedace in five areas. However, even though fish were usually found in those locations, numbers were typically low (<100 fish) and tended to fluctuate, except on the Rock Art Ranch where numbers of spinedace tended to be much higher. Total adult population size is unknown but small. This species is uncommon and highly localized. Genetic data indicate the importance of maintaining all remaining populations (Tibbets et al. 2001). The spinedace consists of four genetically distinct populations (Tibbets et al. 2001; Grover et al. 2019) within the East Clear Creek, Upper Little Colorado River Watershed (upstream of Lyman Reservoir), Chevelon Creek, and Silver Creek watersheds, which we provide current information on below (USFWS, 2023).

Threats and Stressors

Stressor: Habitat loss and fragmentation
Exposure: Not assessed; see narrative
Response: Not assessed; see narrative
Consequence: Not assessed; see narrative
Narrative: At the time of listing in 1987, significant reductions in stream and river habitat from impoundments and water development, and predation by and competitionwith non-native fishes had resulted in habitat loss and fragmentation throughout the spinedace's range. Habitat loss and fragmentation continue to be serious threats to the fish's existence. The final listing rule (USFWS 1987) also identified human uses, such as riparian destruction, urban growth, mining, timber harvest, road construction, livestock grazing, and other watershed disturbances (e.g., road

construction and maintenance, recreational development and usage, fire management, and inter-basin water diversions) as having had detrimental effects to spinedace habitat. These activities have affected watershed function, runoff patterns, peak flows, seasonal flows, riparian vegetation, wet meadow functions, bank erosion, siltation, and water quality. Wildlife and fisheries management largely associated with providing hunting or fishing opportunities has altered the faunal component of the habitat. Introduction of non-native trout, baitfish, and crayfish at recreational lakes and reservoirs have increased competition for available resources and possibly predation on spinedace.

Stressor: Water development
Exposure: Not assessed; see narrative
Response: Not assessed; see narrative
Consequence: Not assessed; see narrative
Narrative: In the Southwest, aquatic habitats have been extensively modified or lost through the construction of dams and water diversions, the channelization of riparian areas, and increasing groundwater withdrawals (Rinne 2004). Many recent studies and assessments of the LCR watershed and its underlying groundwater resources indicate that these water resources are under increasing pressure from development (Bills et al. 2005). The North Central Arizona Water Supply Study Report of Findings (BOR 2006) predicts that by the year 2050, the human demand for water will be unmet in north central Arizona. Plans are underway to determine how additional water resources can be developed to provide for this unmet demand. Protecting water resources for environmental needs is included in these plans. However, it is likely that with the need for additional water for human uses, there would be additional stress put on environmental demands for water. In addition, there is high potential that extended drought, perhaps exacerbated through global climate change, will further stress water resources within the range of the spinedace.

Stressor: Drought and climate change
Exposure: Not assessed; see narrative
Response: Not assessed; see narrative
Consequence: Not assessed; see narrative
Narrative: Continued drought and global climate change are likely to threaten spinedace. Studies have shown that since 1950, the snowmelt season in some watersheds of the western U.S. has advanced by about 10 days (Dettinger and Cayan 1995, Dettinger and Diaz 2000, Stewart et al. 2004). Such changes in the timing and amount of snowmelt are thought to be signals of climate change in high elevations (Smith et al. 2000, Reiners et al. 2003). The impact of climate change is the intensification of natural drought cycles and the ensuing stress placed upon high elevation montane habitats (IPCC 2007, Cook et al. 2004, Breshears et al. 2005, Mueller et al. 2005). Based upon the extended drought in the Southwest and documented changes in spinedace habitats in Arizona, climate change may permanently reduce the amount of habitat available for spinedace. Literature indicates that persistence is greater for species occupying larger patches of theirhistorical range (Channell and Lomolino 2000). Since spinedace occupy small patches of habitat compared to their historical distribution, we may expect thatclimate change would exacerbate the threat of habitat loss and result in further fragmentation among existing populations. It has become more difficult to find spinedace because drought conditions have reduced available habitat. In addition, drought conditions over the last decade have confounded cooperative recovery efforts for the Little Colorado spinedace throughout its range, as Efforts to establish spinedace in additional habitats within currently occupied drainages have been

thwarted over the last several years as spinedace were introduced to areas only to have the habitat dry within months of reintroduction. The lack of permanent waters within the range of the spinedace continues to impede recovery efforts.

Stressor: Nonnative fishes
Exposure: Not assessed; see narrative
Response: Not assessed; see narrative
Consequence: Not assessed; see narrative
Narrative: In the listing decision, predation by non-native piscivorous fish was considered to be a major factor impacting the decline of the spinedace. Since the spinedace was listed, non-native fish and crayfish have continued to increase within the range of the spinedace and is likely one of the reasons the spinedace is so rare throughout the majority of its historical range. It is likely that competition and predation by non-native aquatic species is the most consequential factor preventing the recovery of spinedace and other native aquatic species in the Southwest (Rinne 2004, Clarkson et al. 2005, Olden and Poff 2005, Schade and Bonar 2005). Since listing, several studies have documented the potential adverse effects of nonnative fishes and crayfish on spinedace (Blinn et al. 1993, White 1995, Bryan et al. 2002, Sweetser et al. 2002). However, most of the research and effort to document predation has focused on rainbow trout. Though trout are adocumented predator of spinedace (Blinn et al. 1993) and may interact with other predators to increase detrimental effects to spinedace (Bryan et al. 2002), introduced trout species are not likely the greatest non-native threat to spinedace at this time due to their inability to reproduce outside of reservoirs and AGFD's management of rainbow trout as a put-and-take fishery. Based on data in our files, invasive species such as smallmouth bass and green sunfish, which are extremely piscivorous fish, are increasing in abundance and distribution throughout the range of the spinedace. In addition to predation, non-native fishes may also spread parasites that can cause high fish mortality in new host species (Stone et al. 2007).

Recovery

Reclassification Criteria:
Recovery Priority Number: 2

Delisting Criteria:
Little Colorado spinedace may be considered for delisting when the following criteria are met: 1. Maintain a minimum of 5 viable populations for each of the 3 lineages of Little Colorado spinedace (15 viable populations in total). We chose five viable populations because given the trends in habitat availability and quality, it represents the confluence of what is available and what is meaningful. This will require significant stressor and habitat management to achieve. There are currently three viable populations of the East Clear Creek lineage (West Leonard/Leonard Canyon, Bear Canyon, and Dane Canyon); likely one viable population in the Chevelon Canyon (The Steps); and two to three viable populations in the LCR (Table 1). This will require us to reintroduce populations to areas within these geographic locations. We will not consider reintroduced populations established until they have persisted for a minimum of five years, as is currently defined in the Recovery Plan. Five years is an appropriate timeframe because it allows for multiple reproduction events and monitoring to document juvenile recruitment. Little Colorado spinedace are short-lived fish, and a population is unlikely to persist for more than five years in the absence of juvenile recruitment or augmentation (USFWS 1998). In addition, based on past spinedace establishment efforts, reintroduced populations that

maintain themselves for five years are likely to demonstrate long-term persistence. Due to climate change and groundwater withdrawals, perennial habitat suitable for spinedace is limited in Chevelon Canyon. Based on this information, perennial water in the Chevelon Creek watershed is likely to become increasingly scarce; and it is unlikely that the watershed will support five viable populations. Therefore, although the Recovery Plan does not address this situation, we may need to work with partners to identify locations outside of this watershed, but within the range of the spinedace to establish viable populations of this lineage to ensure the lineage if replicated sufficiently. If we need to identify habitats for the Chevelon Creek spinedace lineage outside of Chevelon Creek, we will identify habitats unlikely to connect to the other two lineages in order ensure long-term viability of the lineage. Any populations of the Chevelon Creek spinedace lineage that become established outside of the Chevelon Creek watershed will improve the redundancy of the source population and serve as sources for reintroduction of individuals to historically occupied habitats within the watershed should the opportunity arise. 2. Maintain a minimum of five core habitat and core recovery areas for the viable populations within each of the main watersheds that support Little Colorado spinedace (Clear Creek, Chevelon Canyon, and LCR watersheds). These areas must show resistance to long-term drought and climate change and be free of warm water nonnatives that predate upon and compete with Little Colorado spinedace (such as green sunfish and smallmouth bass [Micropterus dolomieu]). Protecting existing populations of Little Colorado spinedace will require maintaining core habitats through habitat protection and any necessary restoration or enhancement efforts, combined with removal of any non-native fishes that pose a potential threat to Little Colorado spinedace. 3. Establish at least one refugia for each of the Little Colorado spinedace lineages. Each refugia must have a genetic management plan that ensures the lineage is maintained or enhanced. Establish refugia in the most natural identifiable habitats within the probable historic range. Justification: A refugia is a site with an artificial environment or a modified off-channel habitat in which we maintain Little Colorado spinedace as broodstock and/or to contribute to the preservation of the genetic diversity of a specific lineage. (USFWS, 2019).

Recovery Actions:

- USFWS, AGFD, Forest Service, and other cooperators develop and implement a plan to remove warm-water non-native fishes and manage upper Chevelon Creek (including tributaries, reservoirs, and stock tanks) down through Chevelon Creek Reservoir for native aquatic species within the next 3 to 5 years. Upper Chevelon Creek should maintain surface flow in the foreseeable future as the headwater water rights for the reservoirs are held by AGFD (Willow Springs Lake, Woods Canyon Lake, and Bear Canyon Lake), and the Forest Service (Apache-Sitgreaves National Forest) manages the land base for the entire upper watershed. Sport-fishing opportunities in this watershed could include roundtail chub and native trout species.
- USFWS, AGFD, Forest Service, and other cooperators develop and implement a plan to renovate C.C. Cragin Reservoir to remove warmwater non-native fishes and manage the watershed for native aquatic species. The removal of green sunfish, yellow-bullhead, and largemouth bass from the reservoir would prevent these species from accessing occupied habitats above the reservoir and assist in maintaining and enhancing spinedace populations within the watershed.
- USFWS, AGFD, and other partners work with private land owners and Federal land-management agencies along Silver Creek to develop a comprehensive management plan for the watershed. We need to develop a plan for the watershed that addresses the

management of non-native species.

- USFWS, AGFD, and other partners work with Federal and non-Federal entities to ensure that environmental flows are protected in future water development plans within the historical range of the spinedace. Efforts to work with the Coconino Plateau Water Advisory Council and the Bureau of Reclamation regarding future water use on the Coconino Plateau may assist with this effort. In addition, the USFWS should actively work with non-Federal water users to determine if Habitat Conservation Plans, Safe Harbor Agreements, or cooperative conservation efforts may be options for maintaining instream flow.
- USFWS, AGFD, Forest Service, and other partners evaluate the LCR watershed and identify portions of the watershed that would be managed for native fish (including the spinedace), and actions required in these areas to support native species. The replication of each sub-group within its portion of the watershed into perennial waters not subject to drying due to extended drought or at risk of loss due to new surface or groundwater pumping would provide stability for the species over time.
- Forest Service, AGFD, USFWS, and other partners continue to implement and support the East Clear Creek Watershed Recovery Strategy for the Little Colorado Spinedace and other Riparian Species. The actions that have been implemented to date, particularly the supplemental stocking of spinedace and improved livestock management, have greatly assisted in sustaining spinedace within the East Clear Creek Watershed.
- USFWS take an active leadership role to work with our state and Federal partners to initiate a preliminary program of aggressive development of novel technologies to assist with the control of invasive non-native fishes and other aquatic organisms. These technologies could be applied in the Southwest and elsewhere. We will be unable to meet many of our aquatic species recovery goals if we are unable to control aquatic invasive species. The Little Colorado spinedace is one of many species currently threatened with extinction due to our inability to control invasive species, such as crayfish. Increased ability to control invasive aquatic species would also support the Region 2 Strategic Habitat Conservation goals and the State's Wildlife Action Plans.
- The Recovery Plan be updated and revised to include objective and measurable delisting criteria that address the five-listing factors as required by section 4(f)(1)(B)(ii) of the Act.
- Recovery Priority Number: The current listing and reclassification priority number for Little Colorado spinedace is 2 (high degree of threat/high recovery potential). We do not recommend a change at this time (USFWS, 2018).
- ECOMMENDATIONS FOR FUTURE ACTIONS. We will work with our partners to implement the following recommended actions during the next five-year review period: • Update and revise the Recovery Plan to include objective and measurable delisting criteria that address the five-listing factors as required by section 4(f)(1)(B)(ii) of the Act. This process should include the development of a definition for what constitutes a population. This action will be completed by December 29, 2018. • Evaluate the work conducted in the East Clear Creek watershed, particularly the identification and stocking of suitable habitats and stressor (non-native fishes) removal to the Chevelon Creek, Nutrioso/Rudd Creek, and Little Colorado River drainages. • Work with Federal and non-Federal entities to ensure that environmental flows are protected in future water development plans within the historical range of the spinedace. Efforts to work with the Coconino Plateau Water Advisory Council and the Bureau of Reclamation regarding future water use on the Coconino Plateau may assist with this effort. In addition, the USFWS should actively work with non-Federal water users to determine if Habitat Conservation Plans, Safe Harbor Agreements, or other cooperative

conservation efforts may be options for maintaining instream flow. • Evaluate the LCR watershed and identify portions of the watershed to be managed for native fish (including the spinedace), and actions required in these areas to support native species. Establishing new locations within perennial waters in the watershed not subject to drying due to extended drought or at risk of loss due to new surface or groundwater pumping would provide stability for the species over time. • Continue to implement and support the East Clear Creek Watershed Recovery Strategy for the Little Colorado Spinedace and other Riparian Species. The actions implemented to date, particularly the supplemental stocking of spinedace and improved livestock management, have greatly assisted in sustaining spinedace within the East Clear Creek Watershed. • Continue to take an active leadership role to work with other state and Federal partners to initiate a program of aggressive development of novel technologies to assist with the control of invasive non-native fishes and other aquatic organisms. The Little Colorado spinedace is one of many species currently threatened with extinction due to our inability to control non-native and invasive species, such as crayfish and green sunfish. • Work with private land owners and Federal land-management agencies along Silver Creek to develop a comprehensive management plan for the watershed. Develop a plan for the watershed that addresses water quality, water quantity, and management of non-native species (USFWS, 2018).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS We will work with our partners to implement the following recommended actions during the next five-year review period: • Work with Federal and non-Federal entities to protect environmental (instream) flows in future water development plans within the historical range of the spinedace. Continued efforts to work with the Coconino Plateau Water Advisory Council and the Bureau of Reclamation regarding future water use on the Coconino Plateau may assist with this effort. In addition, the Service should actively work with non-Federal water users to determine if Habitat Conservation Plans, Safe Harbor Agreements, or other cooperative conservation efforts may be options for maintaining instream flow. • Continue to work with the USFS to implement forest and watershed management plans that reduce the risk of high intensity, landscape level fire that could result in long-term detrimental effects to spinedace habitat. • Work with AZGFD to implement the Watershed Management Plans for the Little Colorado River Watershed, which contains the entire range of the spinedace, to prioritize and implement actions to improve spinedace habitat. • Assist with AZGFD's continued monitoring and mechanical removals, particularly within the East Clear Creek Watershed, until there are solutions to stop the source population of green sunfish from being able to colonize stream habitats in the watershed. • Continue to implement and support the East Clear Creek Watershed Recovery Strategy for the Little Colorado Spinedace and other Riparian Species (USFS 1999). The actions implemented to date, particularly the supplemental stocking of spinedace and improved livestock management, are assisting with sustaining spinedace within the East Clear Creek Watershed. • Continue to work with state and Federal partners to initiate a program of aggressive development of novel technologies to assist with the control of invasive non-native fishes and other aquatic organisms. The spinedace is one of many species currently threatened with extinction due to our inability to control non-native and invasive species, such as crayfish (Orconectes virilis) and green sunfish. • Work with landowners, Federal agencies (such as the Natural Resource Conservation Service), and state agencies (such as AZGFD and Arizona Department of Water Quality) to conduct a habitat assessment in the upper watershed of Silver Creek (USFWS, 2023).

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SPECIES ACCOUNT: *Macrhybopsis tetranema* (Peppered chub)

Species Taxonomic and Listing Information

Listing Status: Endangered (USFWS, 2022)

Physical Description

The peppered chub is a small cyprinid minnow with a fusiform (tapering at both ends) body shape rapidly tapering to a conical head. It has a nearly transparent slender body with dark dots scattered on its back. Generally, adult fish reach a maximum length of 3 inches (in) (77 millimeters (mm)) and do not live beyond 2 years (USFWS, 2022).

Taxonomy

Gilbert first described the peppered chub in 1886 (pp. 208–209). Prior to Eisenhour’s 1999 dissertation (published 2004), the peppered chub was classified as one of six subspecies within the Macrhybopsis aestivalis (commonly: Speckled chub) complex. Eisenhour examined morphometrics (measurements of external shape), meristics (counts of features of fish), pigmentation, and tuberculation across the range of the complex. He concluded that the results supported the recognition of five individual species, including Macrhybopsis tetranema, or peppered chub. (USFWS, 2022)

Historical Range

The peppered chub historically inhabited numerous rivers of the Arkansas River basin and, without the presence of dams or other structures, it is likely that individuals within populations exhibited some level of genetic exchange among these rivers. (USFWS, 2022)

Current Range

The peppered chub is now confined to a single population in the upper portion of the South Canadian River in Texas and New Mexico, which represents approximately 6 percent of the species’ historical range. (USFWS, 2022)

Critical Habitat Designated

Yes; 3/30/2022.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine endangered species status under the Endangered Species Act of 1973 (Act), as amended, for the peppered chub (Macrhybopsis tetranema), a freshwater fish species historically found in Colorado, Kansas, New Mexico, Oklahoma, and Texas, which is now extirpated from all but six percent of its historical range. We also designate critical habitat. In total, approximately 872 river miles (1,404 river kilometers) in New Mexico, Oklahoma, and Texas fall within the boundaries of the critical habitat designation. We are excluding approximately 197 river miles (317 river kilometers) of critical habitat in Kansas that was included in the proposed critical habitat designation. This rule adds the species to the List of Endangered and Threatened Wildlife and extends the Act’s protections to the peppered chub designated critical habitat. (USFWS, 2022)

Critical Habitat Designation

Unit 1: Upper South Canadian River, New Mexico and Texas Unit 1 consists of approximately 197 river miles (rmi) (317 river kilometers (rkm)) comprising a portion of the South Canadian River originating below the Ute Dam west of Logan, New Mexico, and extending downstream to the delta of Lake Meredith, Texas; and a portion of Revuelto Creek originating at the Interstate Highway 40 bridge extending downstream to the confluence with the South Canadian River, New Mexico. Revuelto Creek is an important source of water and sediment for the Upper South Canadian River and is considered occupied. Unit 1 occurs largely within private land or land described as ‘‘other,’’ which is land with non-Federal ownership that could not be determined but is likely to be Tribal or private. Approximately 21 rmi (34 rkm) of adjacent lands are federally owned and managed by the National Park Service, and the Bureau of Reclamation. In addition, several small segments of public lands occur at bridge crossings, road easements, and the like. There are state own lands adjacent to approximately 9 rmi (~15 rkm). The remaining lands are in private ownership status and are adjacent to approximately 167 rmi (~268 rkm) of the unit 1 designation. This unit possesses those characteristics as described by PBF 1 (see Physical or Biological Features Essential to the Conservation of the Species, above). PBFs 2 and 3 are in degraded condition in this unit during some times of the year and are dependent upon water releases from Ute Reservoir, precipitation, and groundwater, but these PBFs are currently sufficient to maintain selfsustaining populations. Water management strategies could enhance PBFs 2 and 3 within this unit. Current management to address native riparian vegetation is ongoing throughout this unit as it pertains to PBF 4; however, additional efforts to improve streamflow and channel morphology/complexity (removal of flow obstructions, restoration of historical channel characteristics, etc.) could further benefit this species. Predatory and other fish that may compete with peppered chub are present in this unit, but any effect to peppered chub resiliency is unclear. Thus, management actions to achieve PBF 5 may be necessary if additional information indicates the species’ resiliency is affected by predation or competition. Unit 2: Lower South Canadian River, Texas and Oklahoma Because we have determined occupied areas alone are not adequate for the conservation of the species, we have evaluated whether any unoccupied areas are essential for the conservation of the species and identified this area as essential for the conservation of the species. Unit 2 comprises approximately 400 rmi (644 rkm) consisting of the South Canadian River originating at the U.S. 83 bridge north of Canadian, Texas, and extending downstream to the U.S. 75 bridge northwest of Calvin, Oklahoma. Unit 2 occurs almost entirely within land under ‘‘other’’ land ownership, as described above under Unit 1. Approximately 13 rmi (21 rkm) is managed by the U.S. Army Corps of Engineers, and approximately >1 rmi (1 rkm) is held in trust by the Bureau of Indian Affairs as Cheyenne-Arapaho Trust Land. In addition, several small segments of public land occur at bridge crossings, road easements, and the like. Historically, peppered chubs were observed in the lower portions of the South Canadian River. Peppered chubs were last reported in the South Canadian River resiliency unit in 1999. Currently, this river supports other pelagic-spawning prairie fish, such as the threatened Arkansas River shiner. This unit has at least one of the PBFs essential to the conservation of the species, and we are reasonably certain that this unit will contribute to the conservation of the species. Although it is considered unoccupied, portions of this unit contain some or all of the PBFs essential for the conservation of the species (see Physical or Biological Features Essential to the Conservation of the Species, above.) Unit 2 possesses those characteristics as described by PBF 1 and is the longest unfragmented river segment within the historical range of the peppered chub. Although we have determined that peppered chubs require 127 rmi of unobstructed river characterized by a complex braided channel and substrates of predominantly sand, with some patches of silt, gravel, and cobble, that is the minimum number of river miles required to adequately facilitate reproduction and maintain a population, assuming all of the physical habitat requirements exist throughout the stretch of river (Service 2022, pp. 32 & 116). In order to establish populations, peppered chub need a longer river length that will not only adequately facilitate reproduction but also population growth (Service 2022, p. 97). Additionally, the required habitat factors (from PBF 1) do not exist throughout the entire river segment and, because the peppered chub has an approximate 2-year life cycle, any additional stream length would guard against extirpation due to multiyear droughts. PBF 2 is degraded in the upper portion of this unit during some times of the year and is dependent upon precipitation and groundwater. Based on available data (OWRB 2017, pp. 39–43), PBF 3 is present throughout this unit. Current management to address native riparian vegetation is ongoing throughout this unit as it pertains to PBF 4; however, these management efforts are not specifically directed at benefiting the peppered chub, and additional management efforts may be necessary. Management actions to control nonnative phreatophytic (deep rooted) vegetation upstream and within the upper portion of this unit could also improve PBF 2 by reducing evapotranspiration. Predatory and other fish that may compete with peppered chub are present in this unit, but any effect to peppered chub resiliency is unclear. Thus, management actions to achieve PBF 5 may be necessary if additional information suggests the species’ resiliency is affected by predation or competition. If a healthy population is established in this unit, it would likely be a moderately to highly resilient population due to longer stream length compared to other units and would increase the species’ redundancy by one population. This unit is essential for the conservation of the species because it will provide habitat for range expansion in portions of known historical habitat that is necessary to increase viability of the species by increasing its resiliency, redundancy, and representation. A portion (approximately 238.2 rmi (383.3 rkm)) of listed Arkansas River shiner critical habitat is present in Unit 2. For these reasons, we are reasonably certain that this unit will contribute to the conservation of the species. Additionally, the need for conservation efforts is recognized and is being discussed by our conservation partners, and researchers are working on methods for restoring and reintroducing the species into unoccupied habitat. The State of Oklahoma has identified the peppered chub as a tier III species of greatest conservation need (moderate level of conservation need) in the Oklahoma Comprehensive Wildlife Conservation Strategy (ODWC 2016, p. 399). The State strategy was developed to articulate the conservation strategies necessary to conserve their rare and declining wildlife species and maintain Oklahoma’s rich biological heritage for present and future generations (ODWC 2016, p. 3). The strategy identifies several general conservation actions that would improve PBFs 2, 3, and 4 and benefit the peppered chub, if a population were established and if the actions were implemented, such as providing funding to landowners to restore channel morphology, water conservation, coordinating further with the Service, and public education (ODWC 2016, pp. 45–46). State and Federal partners have shown interest in propagation and reintroduction efforts for the peppered chub in this area. As previously mentioned, efforts are underway regarding a captive propagation program for peppered chub at the Tishomingo National Fish Hatchery in Oklahoma. The State of Kansas, Tishomingo National Fish Hatchery, and the Oklahoma Fish and Wildlife Conservation Office collaborate regularly on conservation actions. The State of Texas also recognizes the peppered chub as a species of greatest conservation need and gives the species a rank of S1 (i.e., at very high risk of extirpation in the jurisdiction due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors). Texas is one of only two States where the species remains extant. The State has also identified the portion of the Canadian River within the boundaries of the State of Texas (portions of which are currently occupied and unoccupied areas inside this unit) as an ecologically significant stream because it has threatened and endangered species/unique communities present (Texas Water Development Board (TWDB) 2016, p. 8–2).

The Canadian River segment in the panhandle of Texas is also significant because of the presence of unique, exemplary, or unusually extensive natural communities upon which water development projects would have significant detrimental effects (TWDB 2016, p. 8–2). Proposed Unit 3: Arkansas/Ninnescah River, Kansas and Oklahoma Proposed Unit 3 comprised approximately 179 rmi (288 rkm) consisting of the South Fork Ninnescah River originating at the Highway 54/400 bridge east of Pratt, Kansas, and extending downstream to the River Road Bridge east of Newkirk, Oklahoma. The proposed unit occurs almost entirely on land under ‘‘other’’ land ownership, as described above under Unit 1. A small amount of this unit is publicly owned in the form of bridge crossings, road easements, and the like. Peppered chub were observed in the Ninnescah River in surveys between the years 2000 and 2013. We have excluded the entire unit from the final designation (see Exclusions, below). A description and map of this unit is maintained in the proposed rule for this designation (85 FR 77108). Approximately 93 percent of this unit is located in the State of Kansas and contains the PBFs essential for the conservation of the species. In 2021, the State of Kanas signed The Kansas Aquatic Species Conservation Agreement: A Programmatic Safe Harbor Agreement and Candidate Conservation Agreement with Assurances for Fourteen Aquatic Species in Kansas (Agreement) that includes the peppered chub and covers the entire portion of this unit that falls within the boundaries of the State of Kansas. Because of the existence of the Agreement, the remaining 12 miles (less than seven percent) of the unit in Oklahoma no longer meets our criteria for designating critical habitat, we have excluded the entire unit from the final critical habitat designation (see Exclusions, below). Unit 4: Cimarron River and Oklahoma Because we have determined that occupied areas alone are not adequate for the conservation of the species, we evaluated whether any unoccupied areas are essential for the conservation of the species and identified this area as essential for the conservation of the species. Unit 4 comprises approximately 275 rmi (443 rkm) consisting of the Cimarron River originating at the border of Kansas and Oklahoma and extending downstream to the OK 51 bridge northeast of Oilton, Oklahoma. This unit occurs almost entirely on land under ‘‘other’’ land ownership, as described above under Unit 1. Approximately 0.86 rmi (1.38 rkm) is managed by the U.S. Army Corps of Engineers; approximately 0.56 rmi (0.91 rkm) is managed by the Bureau of Land Management; and approximately 0.94 rmi (1.51 rkm) is held in trust by the Bureau of Indian Affairs as Sac and Fox Nation Trust Land and Pawnee Trust Land. In addition, small amounts of the unit are publicly owned in the form of bridge crossings, road easements, and the like. Historically, peppered chubs were observed in the Cimarron River. The peppered chub was last observed in the Cimarron River resiliency unit in 2011. This unit has at least one of the PBFs essential to the conservation of the species, and we are reasonably certain that it will contribute to the conservation of the species. Our specific rationale for this unit can be found below in this unit description. Unit 4 is considered unoccupied; however, portions of this unit contain some or all of the PBFs necessary for the conservation of the species (see Physical or Biological Features Essential to the Conservation of the Species, above.) PBF 1 is present within this unit, as described in the Unit 2 description. PBF 2 is degraded in upstream portions of this unit during some times of the year (absent during elevated drought conditions) and is dependent upon precipitation and groundwater. Based on available data, PBF 3 is present throughout this unit with the exception of PBF 3(iii) (conductivity generally less than 16.2 mS/cm) along an approximate 79-mile portion upstream of Waynoka to Ames, Oklahoma. Management actions would likely be necessary to reduce conductivity in this area (OWRB 2017, pp. 49–56). Current management to enhance native riparian vegetation is ongoing throughout this unit as it pertains to PBF 4 and involves the removal/control of nonnative phreatophytic vegetation such as saltcedar, common reed, etc. Management actions to control nonnative phreatophytic vegetation upstream and within the upper portion of this unit could also improve PBFs 2 and 3 by reducing evapotranspiration. Phreatophytic plants such as saltcedar have high water consumption (increasing evapotranspiration) and stress aquatic habitats by lowering groundwater levels. Predatory and other fish that may compete with peppered chub are present in this unit, but any effect to peppered chub resiliency is unclear. Thus, management actions to achieve PBF 5 may be necessary if additional information indicates the species' resiliency is affected by predation or competition. As discussed above, peppered chub currently has little to no representation and redundancy. If established in this unit, a population would increase redundancy by one population, thereby guarding against catastrophic events, and would increase the species' ecological diversity (representation). This unit is essential for the conservation of the species because it will provide habitat for range expansion in portions of known historical habitat that is necessary to increase viability of the species by increasing its resiliency, redundancy, and representation. Critical habitat for the Arkansas River shiner is present within a portion (approximately 201.5 rmi (324.30 rkm)) of Unit 4 and, accordingly, similar conservation activities are already ongoing. For these reasons, we are reasonably certain that this unit will contribute to the conservation of the species. Additionally, the need for conservation efforts has been recognized and is being discussed by our conservation partners, and methods for restoring and reintroducing the species into unoccupied habitat are ongoing. The State of Oklahoma has identified the peppered chub as a tier III species of greatest conservation need in the Oklahoma Comprehensive Wildlife Conservation Strategy (ODWC 2016, p. 399). The Oklahoma strategy was developed to articulate the conservation strategies necessary to conserve their rare and declining wildlife species and maintain Oklahoma's rich biological heritage for present and future generations (ODWC 2016, p. 3). The strategy identifies several general conservation actions that would improve PBFs 2, 3, and 4 and benefit the peppered chub, if a population were established and if the actions were implemented, such as providing funding to landowners to restore channel morphology, water conservation, coordinating further with the Service, and public education (ODWC 2016, pp. 45–46). Also, in Oklahoma, State and Federal partners have shown interest in propagation and reintroduction efforts for the peppered chub. As previously mentioned, efforts are underway regarding a captive propagation program for peppered chub at the Tishomingo National Fish Hatchery in Oklahoma. It is possible that significant drought conditions in the late 1980s and early 1990s led to the peppered chub decline and eventual extirpation in the Cimarron River (in Unit 4). The current condition of the unit, however, is likely to support populations once again (Service 2022, p. 150). Consequently, the shoal chub (Macrhybobsis hyostoma), a species in the same genus as the peppered chub, has reestablished populations and continues to persist in the Cimarron River after previously experiencing significant declines (Lutrell et al. 1999, pp. 984–985), demonstrating that this unit would similarly be suitable for the peppered chub. A relatively small portion of Unit 4 extends into the State of Kansas (approximately six percent) and is covered by The Kansas Aquatic Species Conservation Agreement: A Programmatic Safe Harbor Agreement and Candidate Conservation Agreement with Assurances for Fourteen Aquatic Species in Kansas. We have excluded approximately 17 miles (27 kilometers) of this unit from the final critical habitat designation because the benefits of exclusions outweigh the benefits of inclusion (see Exclusions, below). (USFWS, 2022)

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of peppered chub consist of the following components:

(i) Unobstructed river segments greater than 127 river miles (205 river kilometers) in length that are characterized by a complex braided channel and substrates of predominantly sand, with some patches of silt, gravel, and cobble.

(ii) Flowing water with adequate depths to support all life stages and episodes of elevated discharge to facilitate successful reproduction, channel and floodplain maintenance, and sediment transportation.

(iii) Water of sufficient quality to support survival and reproduction, which includes, but is not limited to, the following conditions: (A) Water temperatures generally less than 98.2 °F (36.8 °C); (B) Dissolved oxygen concentrations generally greater than 3.7 parts per million (ppm); (C) Conductivity generally less than 16.2 millisiemens per centimeter (mS/ cm); (D) pH generally ranging from 5.6 to 9.0; and (E) Sufficiently low petroleum and other pollutant concentrations such that reproduction and/or growth is not impaired.

(iv) Native riparian vegetation capable of maintaining river water quality, providing a terrestrial prey base, and maintaining a healthy riparian ecosystem.

(v) A level of predatory or competitive, native or nonnative fish present such that any peppered chub population's resiliency is not affected.

Special Management Considerations or Protections

The features essential to the conservation of the peppered chub may require special management considerations or protections to reduce the following threats: (1) Altered flow regimes, including (but not limited to) dams and impoundments and groundwater extraction; (2) stream fragmentation; (3) modified geomorphology; (4) poor water quality; (5) impacts from introduction of invasive species (fish and vegetation) and the introduction of native competitors for sport fishing; and (6) other stressors including (but not limited to) gravel mining and dredging, commercial bait fish harvesting, and offroad vehicle use. Management activities that could ameliorate these threats include, but are not limited to: Development of groundwater conservation strategies; removal of impoundments or creation of fish passage, development of water release strategies for reservoirs; minimization of in-channel work from utility or road projects; maintenance of bank stability and revegetation of impacted areas; incorporation of integrated pest management strategies (for saltcedar (Tamarix spp.) and other invasive plants); and development of best management practices to reduce pollutant discharges and to develop water conservation measures that reduce the need for water diversions. (USFWS, 2022)

Life History

Food/Nutrient Resources

Food Source

Adult: They feed primarily on larval insects, small crustaceans, immature aquatic insects, and plant material (USFWS, 2018)

Food/Nutrient Narrative

Adult: Peppered chubs are generalist feeders that feed aggressively to fuel rapid growth (Bottrell et al. 1964, p. 398). Peppered chubs have evolved for feeding in highly turbid streams.

Bonner and Wilde (2002) found that prey consumption by peppered chubs only decreased 21 percent over increasing turbidity (from 0 to 4000 nephelometric turbidity units (NTUs)). Comparatively, Arkansas River shiner (also tolerant of high turbidity) prey consumption decreased by 59 percent over the same gradient (Bonner and Wilde 2002, p. 1203). Peppered chubs have barbels, large olfactory lamellae, and taste buds covering their bodies, including their eyes (Bonner and Wilde 2002, p. 1206). These adaptations help them find prey in turbid waters where sight feeding is difficult. They feed primarily on larval insects, small crustaceans, immature aquatic insects, and plant material (Pflieger 1975 p. 138; Robison and Buchanan, 1988 p. 183; Wilde et al. 2001, p. 406-407). At about 10 days old, they begin to forage among sediments on the river bottom. They also sometimes rise to the top and hit the surface to dislodge food (held by surface tension) (Bottrell et al. 1964, p. 398). Wilde et al. (2001, p. 407) describes peppered chubs as feeding “at or near the substrate.” Pflieger (1975 p. 138) described their feeding as follows: they “swim slowly about with the pectoral fins widespread and the rather long barbels in contact with the bottom. Large quantities of sand are taken into the mouth, sorted for any food it may contain, and then ejected from the mouth and gill openings.” (USFWS, 2018)

Reproductive Strategy

Adult: Broadcast spawning/Oviparity (USFWS, 2018)

Lifespan

Adult: 2 years (USFWS, 2022)

Reproduction Narrative

Adult: Prairie stream fish such as the Arkansas River shiner and peppered chub are members of a reproductive guild that broadcast spawns semibuoyant eggs, which are kept suspended until hatching in flowing water. This reproductive strategy appears to be an adaptation to highly variable environments where stream flows are unpredictable and suspended sediments and shifting sand can cover eggs laid in nests or crevices (Bonner 2000, p. 35). Once saturated with water after spawning, semibuoyant eggs remain suspended in the water column as long as current is present. For peppered chub, fertilized eggs develop as they drift in the current and hatch 25-28 hours after fertilization. (Bottrell et al. 1964, p. 398; Robison and Buchanan 1988 p. 183). Bottrell et al. (1964, pp. 395, 397) found that captive raised peppered chub eggs hatched on average 25.5 hours after fertilization and “on the third day the young fish begins to swim with purposeful movements and to take food” (Bottrell et al. 1964, p. 397). For Arkansas River shiner, approximately 3 days elapse between the time of spawning and the time that the larvae are capable of horizontal movement. Therefore, under flowing water conditions, eggs and developing young are swept downstream from their parent locality (Moore 1944, pp. 211-212). Without stream flow, eggs sink to the bottom where they may be covered with silt and die (Platania and Altenbach 1998, p. 565). The duration of the drift stage (eggs and fry incapable of deliberate movement) is dependent on developmental rate, which is correlated with water temperature. However, the distance eggs and larvae are transported during the drift phase is dependent not only on rate of development but also on river morphology and water velocity during the 3-5 day period immediately after spawning (Platania and Altenbach 1998, p. 566). Specifics related to the reproductive strategies of the pelagic broadcast spawning Arkansas River shiner and peppered chub and their physical population requirements related to reproduction (stream flow, stream length and connectivity, channel complexity, etc.) are discussed further within this section.   Peppered chubs deposit semi-buoyant eggs broadcast into strong currents when water temperatures reach 21°C, usually between May and August (Cross and Collins 1995, Robison and Buchanan 1988 p. 183; Bottrell et al 1964, p. 393). This provides sufficient oxygen for developing eggs in highly turbid streams. Fertilized eggs develop as they drift in the current, and hatch 25-28 hours after fertilization (Bottrell et al 1964, p. 398; Robison and Buchanan 1988 p. 183). Larval fish may require strong currents to keep them suspended in the water column until they are strong enough to leave the main channel (Wilde et al. 2000, p. 107). Little is known about the streamflow requirements of juvenile peppered chubs, but it is assumed to be similar to adult fish. Adult peppered chubs prefer shallow channels where currents flow over clean fine sand (Cross and Collins 1995 p. 62; Collins et al. 1995 p. 45), avoid calm waters and silted stream bottoms and are more adapted for headwaters of streams than other members of the M. aestivalis complex (Layher and Brinkman 2005, p. 5). Peppered chubs typically select swifter currents than the Arkansas River shiner during winter, spring, and summer (Bonner 2000, p. 8). Like the Arkansas River shiner, the peppered chub has been observed to spawn multiple times during the spawning season, under a variety of flow regimes, from no flow to high flow (Bonner 2000, p. 34), but periods of flowing water are essential for reproductive success. It is not known whether eggs spawned and hatched in isolated pools (without flow) survive (Wilde et al. 2000, p. 107). Therefore, minimal low flows may be important for maintaining population numbers as they allow for reproduction throughout the summer. (USFWS, 2018)

Habitat Type

Adult: rivers/large streams (USFWS, 2022)

Geographic or Habitat Restraints or Barriers

Adult: Dams/Impoundments (USFWS, 2022)

Environmental Specificity

Adult: Broad/Generalist (USFWS, 2022)

Habitat Narrative

Adult: Habitat for the peppered chub historically consisted of the main channels of wide, shallow, sandy-bottomed rivers and larger streams of the Arkansas River basin, with a noted preference for river segments nearer the headwaters, as compared to other Macrhybopsis in the Arkansas River basin. Adults prefer shallow channels where currents flow over clean fine sand and generally avoid calm waters and silted river bottoms. Peppered chub have key adaptations that enable them to tolerate the adverse conditions of the drought-prone prairie rivers that they inhabit, including a relatively high capacity to endure elevated temperatures and low dissolved oxygen concentrations. They also appear to be often associated with turbid waters. (USFWS, 2022)

Dispersal/Migration

Dispersal/Migration Narrative

Adult: The Arkansas River shiner and peppered chub historically inhabited numerous rivers across the Arkansas River drainage (see historical distribution maps in Chapter 2). We conclude that dispersion between major rivers occurred historically, but each of the major rivers supported 'local populations.' (USFWS, 2018)

Population Information and Trends

Population Trends:
Decreasing

Number of Populations:
1 (USFWS, 2018)

Additional Population-level Information:
Additionally, peppered chubs were not collected in the Ninnescah River during the 2013 to 2017 time period (which coincided with local drought conditions). The drought impacts resulted in the only remaining extant population being documented in the upper South Canadian River, which had declined 45 percent from previous survey results, based on the ratio of present versus absent sites. Peppered chub distribution is currently limited to the South Canadian River between Ute Reservoir in New Mexico and Lake Meredith in the Texas panhandle, which represents only 6 percent of its historical range (USFWS, 2022).

Population Narrative:
The South Canadian River, containing the only extant population of the peppered chub, is known to periodically recede, leaving peppered chubs stranded in shorter river segments and isolated pools, especially during times of drought. The lifespan of peppered chubs is short enough that two or more successive years of isolation (especially during peak reproductive season) in segments substantially shorter than the aforementioned estimated length required for population sustainment may lead to extirpation (USFWS, 2022).

Threats and Stressors

Stressor: Impoundments (USFWS, 2018)
Exposure:
Response:
Consequence:
Narrative: Demand for water in the Arkansas River drainage has led to the construction of at least 50 major reservoirs in Arkansas, Colorado, Kansas, New Mexico, Oklahoma, and Texas (Bonner & Wilde 2000, p. 189). Impoundments and fragmentation of streams have altered the timing, duration and magnitude of flows throughout the Arkansas River basin. Barriers to fish movement have acted as a ratcheting mechanism (irreversible by natural process) contributing to local extirpations (Perkin et al. 2017, p. 7374). Arkansas River shiner and peppered chub have been functionally extirpated from 83 percent and 94 percent of their respective range (63 FR 64772; Luttrell et al. 1999, p. 981; as analyzed in Chapter 4 of this report). The decline in distribution of both species in the past is the result of stream fragmentation, stream dewatering, habitat degradation and altered stream flow and dynamics. Inundation (formation of lakes and smaller lentic habitats) has primarily occurred upstream of dams, both large (such as Ute, Sanford, and Eufaula Dams on the South Canadian River) and small (watershed dams for flood control, low water crossings, diversion dams, etc.). Inundation causes an increase in sediment deposition; deep, colder water often devoid of oxygen and necessary nutrients; and proliferation of predator species which prefer deep water habitats. The negative effects of impoundments on riverine systems, including changed temperature regimes, flow regimes, substrates, sedimentation, water quality, channel morphology, and nutrient availability, and their action as

barriers to fish passage, are well documented (Bonner and Wilde 2000, p. 189; Schrank et al. 2001, p. 419; Bunn and Arthington 2002, p. 495; Eberle et al. 2002, p. 186; Mammoliti 2002, pp. 223–226; Quist et al. 2005, p. 53; Dudley and Platania 2007, p. 2081; Suttkus and Mettee 2009, p. 3; Perkin et al. 2010, p. 2; Perkin and Gido 2011, pp. 379–380). Main channel impoundments, tributary impoundments, and off-channel reservoirs alter the natural flow regime upon which the entire river ecosystem is adapted (Poff et al. 1997, p. 772; Bunn and Arthington 2002, p. 492; Richter et al. 2003, p. 207). The components of the flow regime include the magnitude, frequency, duration, predictability, and rate of change of hydrologic conditions (Poff et al. 1997, p. 770). The consequences of impoundments on both upstream and downstream fish assemblages are well documented in many river systems. In the Solomon River basin of Kansas, Eberle et al. (2002, p. 188) discovered that the plains minnow (Hybognathus placitus) has been extirpated due to conversion of sandy, braided channels to non-sandy, narrow channels following impoundment. The authors also found that 18 fish species were introduced or immigrated into the altered system, where increased competition from non-native species may have contributed to the decline of native fish species (Eberle et al. 2002, p. 182). In the South Canadian River in Texas, the plains minnow and Arkansas River shiner comprised approximately 96 percent of the fish assemblage prior to impoundment of Lake Meredith and less than 1 percent downstream of the dam after impoundment (Bonner and Wilde 2000, pp. 192–193). At least two other cyprinid species, including the peppered chub, have disappeared downstream of Lake Meredith, while two other species have become much more common and now dominate the assemblage (Bonner and Wilde 2000, p. 193). These examples illustrate the effects impoundments can have on fish species assemblages, including broadcast-spawning minnows native to prairie streams and their potential replacement by other species. Reduced water velocities upstream from impoundments increase the likelihood of the establishment of new species or increased abundance of existing species more adapted to the lentic (no flow or still waters) environment (Poff et al. 1997, p. 776). Lentic fish species are often top predators and can have negative impacts on smaller, riverine species (Poff et al. 1997, p. 777; Mammoliti 2002, p. 223). Downstream flood frequencies are also altered by impoundments. Prior to the completion of Ute Dam in 1963, the flow at the downstream gage (USGS Station Number 07227000) having a 10-year recurrence interval was 2,461 cubic meter per second (cms) (86,920 cubic feet per second (cfs)). After completion of the dam, the flow with this recurrence interval was only 73 cms (2,584 cfs), a 97.0 percent reduction. Mean flow at this gage prior to impoundment was 8.5 cms (299 cfs); after impoundment mean flow dropped to 0.9 cms (32.7 cfs), an 89.1 percent decrease. Similarly, before Sanford Dam formed Lake Meredith in 1965, the flow at the downstream gage near Canadian, Texas (USGS Station Number 07228000) having a 10-year recurrence interval was 2,371 cms (83,730 cfs). Following completion of the dam, the flow with the same recurrence interval fell to only 427.6 cms (15,100 cfs), an 82 percent reduction. Mean flow at this gage before impoundment was 15.5 cms (548 cfs). Subsequent to impoundment, mean flow was reduced to 2.2 cms (77.1 cfs), an 85.9 percent decline. The shifts in flood frequencies and annual mean discharges appear to favor fish adapted to less variable flows over obligate riverine broadcast-spawners, such as the Arkansas River shiner and peppered chub. The loss of seasonal peak flows disrupts spawning and larval development (Poff et al. 1997, p. 776), which is of concern for broadcast spawning fish such as the Arkansas River shiner and peppered chub. Virtually every broadcast spawning fish endemic to the Great Plains has been affected by habitat fragmentation and stream dewatering. Arkansas River shiners and peppered chubs suffer direct mortality to all life stages when rivers dry. No flow conditions may result in the disruption of spawning when adults are trapped in isolated pools within intermittent reaches, and poor recruitment of juveniles when habitat required for larvae and juveniles is limited or lacking (USFWS, 2018)

Stressor: Groundwater Losses (USFWS, 2018)
Exposure:
Response:
Consequence:
Narrative: Groundwater underlies much of the earth's surface, and in many places it is in direct contact with surface-water bodies (Winter 2007, p. 23). Most streams require some contribution from groundwater to provide reliable habitat for aquatic organisms (Winter 2007, p. 15). Although drought is a naturally occurring phenomenon in Great Plains streams, overexploitation of groundwater resources has contributed to a permanent decline in streamflow and the subsequent loss of pelagic broadcast spawning fishes in streams that are decoupled from aquifers because of groundwater depletion (Perkin et al. 2017, p. 7374). Modeling by Perkin et al. (2017) provided evidence that ground water pumping over the past half-century has caused declines of stream length within the Great Plains. This decline in prevalence of lengthy steams, confounded by the concurrent increase in impoundments, coincided with a decline in fish species that require longer stream lengths, and has greatly altered fish assemblages (Perkin et al. 2017, p. 7375-7376). (USFWS, 2018)

Stressor: Climate Effects on Precipitation and Drought (USFWS, 2018)
Exposure:
Response:
Consequence:
Narrative: Scientific measurements spanning several decades demonstrate that changes in climate are occurring and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system overall and substantial changes in precipitation in some regions of the world, including increases in extreme drought and flood events. (For these and other examples, see IPCC 2014, pp. 7, 40-54). The main scientific measure of climate change, the earth's average annual temperature (the surface air temperature above land and oceans), shows clear evidence of the change since modern recordkeeping began in 1880 (Figure 3-3). (USFWS, 2018)

Stressor: STREAM FRAGMENTATION (USFWS, 2018)
Exposure:
Response:
Consequence:
Narrative: Dams fragment habitat and create physical barriers to the movement of fish. Although freeswimming fish and early life-history stages would likely be capable of passing downstream through small fish barriers such as weirs (low dams built to raise the level of water upstream), low-water crossings, and natural or manmade falls, adults and larval stages of Arkansas River shiners and peppered chubs are not likely capable of passing downstream through most reservoirs large enough to act as water supply or hydroelectric sources. Likewise, due to the small size and limited swimming ability of these species, upstream movement of adults would likely be prohibited by nearly any fish barrier including impoundments (regardless of type or function), weirs, falls, pipeline reinforcements structures, and some low-water crossings. Even in the event ichthyoplanktonic stages of either species are capable of passing over a fish barrier, existing adult fish typically remain isolated below the barrier, unable to return to spawning areas upstream and prohibiting successive reproductive efforts. Because of their reproductive need for unimpounded flowing water, both species have been eliminated from short fragments and

typically persist only in river segments that are at a minimum of 217 river kilometers (km) (135 miles (mi)) in length for Arkansas River shiner, and 205 river km (127 mi) in length for peppered chub (Perkin and Gido 2011, p. 374). The blocking of movement of adult fish also limits their ability to seek suitable habitat during drought conditions. (USFWS, 2018)

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

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References

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SPECIES ACCOUNT: *Meda fulgida* (Spikedace)

Species Taxonomic and Listing Information

Listing Status: Endangered; February 23, 2012 (uplisted from Threatened); Southwest Region (R2)

Physical Description

Adult spikedace are typically less than 70 mm in total length (TL), slim, and slightly compressed laterally. Scales are present only as small plates deeply embedded in the skin. The dorsal fin has a short base with usually seven rays, the first two being spinose, the anterior one being grooved to receive the second. The first spinous ray of the dorsal fin is stronger than the second, almost as long, and sharply pointed. Anal fins usually have 9 rays. Medial edges of the pelvic fins are adnate to the belly. The eyes and mouth are both relatively large and barbels are absent. Pharyngeal teeth are typically 1,4-4,1. The sides are silvery with vertically elongated black specks. The dorsum is olive-gray to brownish, usually mottled with darker pigmentation while the belly is white. Breeding males have a golden or brassy sheen, especially on the head and at bases of fins.

Current Range

U.S.: Gila, Graham, Greenlee, Pinal, and Yavapai counties, Arizona; Catron, Grant, and Hidalgo counties, New Mexico. Mexico

Distinct Population Segments Defined

No.

Critical Habitat Designated

Yes; 2/23/2012.

Legal Description

On February 23, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Meda fulgida (Spikedace) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes eight critical habitat units (CHUs) in Arizona and New Mexico (77 FR 10810-10932).
The critical habitat designation for Meda fulgida includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Meda fulgida.

Critical Habitat Designation

The critical habitat designation for Meda fulgida includes eight CHUs in Cochise, Gila, Graham, Greenlee, Pinal, and Yavapai Counties, Arizona, and Catron, Grant, and Hidalgo Counties, New Mexico (77 FR 10810-10932).

Unit 1: Unit 1: Verde River Subbasin, Yavapai County, Arizona. (i) Verde River for approximately 170.6 km (105.9 mi), extending from the confluence with Fossil Creek in Township 11 North, Range 6 East, northeast quarter of section 25 upstream to Sullivan Dam in Township 17 North, Range 2 West, northwest quarter of section 15. This mileage does not include the 1.2 km (0.8 mi) belonging to the Yavapai-Apache Nation, which is excluded from this designation. Granite Creek for approximately 3.2 km (2.0 mi), extending from the confluence with the Verde River in Township 17 North, Range 2 West, northeast quarter section 14 upstream to a spring in Township 17 North, Range 2 West, southwest quarter of the southwest quarter of section 13. (ii) Oak Creek for approximately 54.3 km (33.7 mi), extending from the confluence with the Verde River in Township 15 North, Range 4 East, southeast quarter section 20 upstream to the confluence with an unnamed tributary from the south in Township 17 North, Range 5 East, southeast quarter of the northeast quarter of section 24. (iii) Beaver Creek/Wet Beaver Creek for approximately 33.3 km (20.7 mi), extending from the confluence with the Verde River in Township 14 North, Range 5 East, southeast quarter of section 30 upstream to the confluence with Casner Canyon in Township 15 North, Range 6 East, northwest quarter of section 23. This mileage does not include the 0.2 km (0.1 mi) belonging to the Yavapai-Apache Nation and excluded from these designations. (iv) West Clear Creek for approximately 10.9 km (6.8. mi), extending from the confluence with the Verde River in Township 13 North, Range 5 East, center section 21, upstream to the confluence with Black Mountain Canyon in Township 13 North, Range 6 East, southeast quarter of section 17. (v) Fossil Creek for approximately 22.2 km (13.8 mi) from its confluence with the Verde River at Township 11 North, Range 6 East, northeast quarter of section 25 upstream to the old Fossil Diversion Dam site at Township 12 North, Range 7 East, southeast quarter of section 14.

Unit 2: Unit 2: Salt River Subbasin, Gila County, Arizona. (i) Tonto Creek for approximately 47.8 km (29.7 mi) extending from the confluence with Greenback Creek in Township 5 North, Range 11 East, northwest quarter of section 8 upstream to the confluence with Houston Creek in Township 9 North, Range 11 East, northeast quarter of section 18. (ii) Greenback Creek for approximately 15.1 km (9.4 mi) from the confluence with Tonto Creek in Township 5 North, Range 11 East, northwest quarter of section 8 upstream to Lime Springs in Township 6 North, Range 12 East, southwest quarter of section 20. (iii) Rye Creek for approximately 2.8 km (1.8 mi) extending from the confluence with Tonto Creek in Township 8 North, Range 10 East, northeast quarter of section 24 upstream to the confluence with Brady Canyon in Township 8 North, Range 10 East, northwest quarter of section 14. (iv) Spring Creek for approximately 27.2 km (16.9 mi) extending from the confluence with the Tonto River at Township 10 North, Range 11 East, southeast quarter of section 36 upstream to the confluence with Sevenmile Canyon at Township 8 North, Range 13 East, northern boundary of section 20. (v) Rock Creek for approximately 5.8 km (3.6 mi) extending from the confluence with Spring Creek at Township 8 North, Range 12 East, southeast quarter of section 1 upstream to the confluence with Buzzard Roost Canyon at Township 8 North, 12 East, center of section 24.

Unit 3: San Pedro River Subbasin, Cochise, Graham, and Pinal Counties, Arizona. (i) Aravaipa Creek for approximately 44.9 km (27.9 mi) extending from the confluence with the San Pedro River in Township 7 South, Range 16 East, center of section 9 upstream to the confluence with Stowe Gulch in Township 6 South, Range 19 East, southeast quarter of the northeast quarter of section 35. Deer Creek—3.7 km (2.3 mi) of the creek extending from the confluence with Aravaipa Creek at Township 6 South, Range 18 East, section 14 upstream to the boundary of the Aravaipa Wilderness at Township 6 South, Range 19 East, section 18. (ii) Turkey Creek—4.3 km (2.7 mi) of the creek extending from the confluence with Aravaipa Creek at Township 6 South, Range 19 East, section 19 upstream to the confluence with Oak Grove Canyon at Township 6 South, Range 19 east, section 32. (iii) Hot Springs Canyon for approximately 9.3 km (5.8 mi) extending from the confluence with Bass Canyon in Township 12 South, Range 20 East, northeast quarter of section 36 downstream to Township 12 South, Range 20 East, southeast quarter of section 32. (iv) Redfield Canyon for approximately 6.5 km (4.0 mi) extending from Township 11 South, Range 19 East, northeast quarter of section 36 upstream to the confluence with Sycamore Canyon in Township 11 South, Range 20 East, northwest quarter of section 28. (v) Bass Canyon for approximately 5.5 km (3.4 mi) from the confluence with Hot Springs Canyon in Township 12 South, Range 20 East, northeast quarter of section 36 upstream to the confluence with Pine Canyon in Township 12 South, Range 21 East, center of section 20.

Unit 4: Bonita Creek Subbasin, Graham County, Arizona. (i) Bonita Creek for approximately 23.8 km (14.8 mi) from the confluence with the Gila River in Township 6 South, Range 28 East, southeast quarter of section 21 upstream to the confluence with Martinez Wash in Township 4 South, Range 27 East, southeast quarter of Section 27.

Unit 5: Eagle Creek Subbasin, Graham and Greenlee Counties, Arizona. (i) Eagle Creek for approximately 26.5 km (16.5 mi) from the FreeportMcMoRan diversion dam at Township 4 South, Range 28 East, southwest quarter of the northwest quarter of section 23 upstream to the confluence of East Eagle Creek in Township 2 North, Range 28 East, southwest quarter of section 20. This mileage does not include approximately 21.4 km (13.3 mi) of Eagle Creek on lands belonging to Freeport-McMoRan, which is excluded from this designation.

Unit 6: San Francisco River Subbasin, Greenlee County, Arizona, and Catron County, New Mexico. (i) San Francisco River for approximately 166.7 km (103.5 mi) of the San Francisco River extending from the confluence with the Gila River in Arizona in Township 5 South, Range 29 East, southeast quarter of section 21 upstream to Township 6 South, Range 19 West, section 2 in New Mexico. This mileage does include approximately 14.1 km (8.8 mi) of the San Francisco River on lands belonging to Freeport-McMoRan, which is excluded from this designation.

Unit 7: Unit 7: Blue River Subbasin, Greenlee County, Arizona, and Catron County, New Mexico. (i) Blue River for approximately 81.4 km (50.6 mi) from the confluence with the San Francisco River at Township 2S., Range 31 East, southeast quarter of section 31 upstream to the confluence of Campbell Blue and Dry Blue Creeks at Township 7 South, Range 21 West, southeast quarter of section 6. (ii) Campbell Blue Creek for approximately 12.4 km (7.7 mi) from the confluence of Dry Blue and Campbell Blue Creeks at Township 7 South, Range 21 West, southeast quarter of section 6 to the confluence with Coleman Canyon in Township 4.5 North, Range 31 East, southwest quarter of the northeast quarter of section 32. (iii) Little Blue Creek for approximately 5.1 km (3.1 mi) from the confluence with the Blue River at Township 1 South, Range 31 East, center Section 5 upstream to the mouth of a canyon at Township 1 North, Range 31 East, northeast quarter of section 29. (iv) Pace Creek for approximately 1.2 km (0.8 mi) from the confluence with Dry Blue Creek at Township 6 South, Range 21 West, southwest quarter of Section 28 upstream to a barrier falls at Township 6 South, Range 21 West, northeast quarter of section 29. (v) Frieborn Creek for approximately 1.8 km (1.1 mi) from the confluence with Dry Blue Creek at Township 7 South, Range 21 West, southwest quarter of the northwest quarter of section 5 upstream to an unnamed tributary flowing from the south in Township 7 South, Range 21 West, northeast quarter of southwest quarter of section 8. (vi) Dry Blue Creek for approximately 4.7 km (3.0 mi) from the confluence with Campbell Blue Creek at Township 7 South, Range 21 West, southeast quarter of Section 6 upstream to the confluence with Pace Creek in Township 6 South, Range 21 West, southwest quarter of section 28.

Unit 8: Gila River Subbasin, Catron, Grant, and Hidalgo Counties, New Mexico. (i) Gila River for approximately 153.5 km (95.4 mi) from the confluence with Moore Canyon at Township 18 South, Range 21 West, southeast quarter of the southwest quarter of section 32 upstream to the confluence of the East and West Forks of the Gila River at Township 13 South, Range 13 West, center of section 8. This mileage does not include approximately 11.5 km (7.2 mi) of the Gila River on lands owned by Freeport-McMoRan, which is excluded from this designation. (ii) West Fork Gila River for approximately 13.0 km (8.1 mi) from the confluence with the East Fork Gila River at Township 13 South, Range 13 West, center of section 8 upstream to the confluence with EE Canyon at Township 12 South, Range 14 West, east boundary of Section 21. (iii) Middle Fork Gila River for approximately 12.5 km (7.7 mi) of the Middle Fork Gila River extending from the confluence with West Fork Gila River at Township 12 South, Range 14 West, southwest quarter of section 25 upstream to the confluence of Big Bear Canyon in Township 12 South, Range 14 West, southwest quarter of section 2. (iv) East Fork Gila River for approximately 42.1 km (26.2 mi) extending from the confluence with West Fork Gila River at Township 13 South, Range 13 West, center of section 8 upstream to the confluence of Beaver and Taylor Creeks in Township 11 South, Range 12 West, northeast quarter of section 17. (v) Mangas Creek for approximately 1.2 km (0.8 mi) extending from Township 17 South, Range 17 West, at the eastern boundary of section 3 upstream to the confluence with Blacksmith Canyon at Township 17 South, Range 17 West, northwest quarter of section 3. This mileage does not include approximately 7.9 km (4.9 mi) of Mangas Creek on lands belonging to Freeport-McMoRan, which are excluded from the designation.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Meda fulgida critical habitat consists of six components in Arizona and New Mexico (77 FR 10810-10932):

(1) Habitat to support all egg, larval, juvenile, and adult spikedace. This habitat includes perennial flows with a stream depth generally less than 1 m (3.3 ft), and with slow to swift flow velocities between 5 and 80 cm per second (1.9 and 31.5 in. per second). Appropriate stream microhabitat types include glides, runs, riffles, the margins of pools and eddies, and backwater components over sand, gravel, and cobble substrates with low or moderate amounts of fine sediment and substrate embeddedness. Appropriate habitat will have a low gradient of less than approximately 1.0 percent, at elevations below 2,100 m (6,890 ft). Water temperatures should be in the general range of 8.0 to 28.0 °C (46.4 to 82.4 °F).

(2) An abundant aquatic insect food base consisting of mayflies, true flies, black flies, caddis flies, stoneflies, and dragonflies.

(3) Streams with no or no more than low levels of pollutants.

(4) Perennial flows or interrupted stream courses that are periodically dewatered but that serve as connective corridors between occupied or seasonally occupied habitat and through which the species may move when the habitat is wetted.

(5) No nonnative aquatic species, or levels of nonnative aquatic species that are sufficiently low to allow persistence of spikedace.

(6) Streams with a natural, unregulated flow regime that allows for periodic flooding or, if flows are modified or regulated, a flow regime that allows for adequate river functions, such as flows capable of transporting sediments.

(8) Areas that need special management or protection to insure razorback survival and recovery. These areas once met the habitat needs of the razorback sucker and may be recoverable with additional protection and management.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas determined to be occupied at the time of listing contain the PBFs and may require special management considerations or protection. We believe each area included in these designations requires special management and protections as described in our unit descriptions. Special management considerations for each area will depend on the threats to the spikedace or loach minnow, or both, in that critical habitat area. For example, threats requiring special management include nonnative fish species and the continued spread of nonnative fishes into spikedace or loach minnow habitat. Other threats requiring special management include the threat of fire, retardant application during fire, and excessive ash and sediment following fire. Poor water quality and adequate quantities of water for all life stages of spikedace and loach minnow threaten these fish and may require special management actions or protections. Certain livestock grazing practices can be a threat to spikedace and loach minnow and their habitats, although concern for this threat has lessened due to improved management practices. The construction of water diversions can cause increasing water depth behind diversion structures, and has reduced or eliminated riffle habitat in many stream reaches. In addition, loach minnow are generally absent in stream reaches affected by impoundments. While the specific factor responsible for this is not known, it is likely related to modification of thermal regimes, habitat, food base, or discharge patterns. We have included below in our description of each of the critical habitat areas for the spikedace and loach minnow a discussion of the threats occurring in that area requiring special management or protections.

Life History

Feeding Narrative

Adult: The majority of the spikedace diet is comprised of a wide variety of small terrestrial and aquatic insects (USFWS 2012 p. 10834). Common prey items include mayflies, caddisflies, trueflies, stoneflies, and dragonflies, but the species will also consume ants, wasps, beetles, and true bugs (Schreiber 1978 pp. 12-16, Propst et al. 1986 p. 59, USFWS 2012 p. 10834). Schreiber and Minckley (1981) reported that up to approximately 30% of the diet was made up of emerging or adult insects. Spikedace also eat (seasonally) some fry of other fish species. In pools, it eats mayflies; the diet is more diverse in riffles and runs. Dipteran larvae are most important for small individuals, mayfly adults and nymphs for adults. Feeding activity peaks in late afternoon and early evening (Barber and Minckley 1983). Spikedace diet also includes branchiopods from the order Cladocera (USFWS 2012 p. 10834). Available prey items incudes water fleas (USFWS 2012 p. 10834). The importance of each prey species may vary depending on season or age class of the spikedace (USFWS 2012 p. 10834).

Reproduction Narrative

Adult: Spikedace breed in spring (April-June); breeding is apparently initiated in response to a combination of stream discharge and water temperature; timing varies annually and geographically (Anderson 1978, Barber et al. 1970, Propst et al. 1986). Males patrol in shallow, sandy-gravelly riffles where current is moderate. There is no indication of territoriality, although males generally remain evenly spaced within an occupied area. Receptive females move into the area, often from up or downstream pools, and are approached at once by up to six males, two of which remain immediately alongside and slightly behind the female. Spawning occurs over shallow (less than 15 cm deep), sand-gravel-bottomed riffles where water flow is moderate (Minckley 1973, Sublette et al. 1990). Gametes are presumably deposited into the water column or on or near the substrate. No fertilized ova have been recovered; however, because they are adhesive and demersal based on eggs stripped and fertilized in the laboratory (P. Turner, per.. comm.), they likely adhere to substrates. The number of eggs per female ranges from 80 to 300 or more depending on female size. Sex ratio among reproductive adults is not constant, varying from near unity among younger fish to a greater abundance of females among older individuals. Females may be fractional spawners, with elapsed periods of a few days to several weeks between spawnings. Fecundity of individual females based on gonad examination ranges from 90 to 250 ova, and is significantly correlated with both length and age. Ovum diameter at spawning is near 1.5 millimeters (mm). No specific information incubation times or size at hatching is available.

Habitat Narrative

Egg: Eggs develop in sand or gravel at spawning site (Sublette et al. 1990). Eggs will settle to the bottom where they will adhere and develop among the sand and gravel substrate of riffles (Propst et al. 1986 p. 40, USFWS 2012 p. 10831). Substrate provides a stable surface for the eggs to adhere to as they settle out of the water column. Adhering to the substrate reduces the risk of washing downstream to sub-optimal habitats. The substrate must contain low levels of fine materials and embededdness to ensure that the eggs are well oxygenated and do not suffocate from the deposition of of silt (USFWS 2012 p. 10831). Stability of the substrate is likely important during times of egg deposition and hatching (Minckley 1981).

Larvae: Upon hatching, larval spikedace disperse downstream to reaches with low-velocity water, typically along stream margins or on the edges of pools (Propst et al. 1986 p. 40, USFWS 2012 p. 10831, Gori et al. 2014 p. 257). Water velocities are substantially slower than those found in adult habitat. Studies of the Gila River found larval spikdace in water velocities that averaged 8.4 cm/sec (Propst et al. 1986 p. 40, USFWS 2012 p. 10836). Larval spikedace may be occasionally found in quiet pools or backwaters (USFWS 2012 p. 10831). These slow, shallow, and warm habitats may act as nursery habitats allowing the larvae to grow and develope while not exceeding its swim capabilities (Gori et al. 2014 p. 257).

Juvenile: Juvenile spikedace are found in slow to moderate water velocities (Propst et al. 1986 p. 41, USFWS 2012 p. 10831, 10836). While typically found in water with faster velocities than larval spikedace, they still occur in water that is lower in velocity than we tend find adults in (Propst et al. 1986 p. 41, USFWS 2012 p. 10836). Juvenile spike dace of the Gila River were found in water velocities that averaged 16.8 cm/sec (Propst et al. 1986 p. 41, USFWS 2012 p. 10836). Juvenile spikedace may be occasionally found in qiuet pools or backwaters (USFWS 2012 p. 10831). Use of slower water than adults may reflect the swim capabilities of the juvenile.

Adult: Habitat includes permanent, flowing, unpolluted water of low gradient streams having pool, riffle, run, and backwater areas; sand, gravel, and cobble substrates with low to moderate amounts of fine sediment and substrate embeddedness; abundant aquatic insects; natural hydrologic conditions, including recurrent flooding; few or no predatory or competitive non-native species present; a healthy riparian community; and moderate to high bank stability (USFWS, Federal Register, 8 March 1994; USFWS 1999). In larger rivers, spikedace often are found in the vicinity of tributary mouths. Spikedace are found in shallow water that is generally < 1 meter in depth (USFWS 2012 p. 10832). The majority of the species occur at water depths < 32 cm (Propst et al. 1986 pp. 40-43). Adult spikedace are primarily found in shallow, turbulent riffle habitat, but can also be found in slightly deeper runs, glides, and occasionally pools (Propst et al. 1986 p. 12, USFWS 2012 p. 10832). Larvae and juvenile spikedace are commonly found in shallow, slow moving water along the stream margins (Propst et al. 1986 p. 40, USFWS 2012 p. 10836). When spawning, male and female spikedace will segregate with males will occupying shallow riffle habitat that is approximately 7.9 - 15.0 cm deep and females occupying slightly deeper pool habitat adjacent to the riffles (Barber et al. 1970 pp. 11-12, USFWS 2012 p. 10836). When females are ready to spawn, they will enter male occupied riffle habitat (Barber et al. 1978 pp. 11-12, USFWS 2012 p. 10836). Spawning occurs over shallow (less than 15 cm deep), sand-gravel-bottomed riffles where water flow is moderate (Minckley 1973, Sublette et al. 1990). The depth at which a species is found may vary slightly depending on its geographic location, habitat availability, and season (propst et al. 47). During warmer months the species will remain in shallower water than during the cold months. Propst et al. (1986) found that the species in the Forks area of the Gila River were most commonly found in water < 16.8 cm deep, but shifted to water that ranged between 16.8-32.1 cm deep during cold months (p. 47). The species use of shallow habitats may reflect habitat availability for arid stream stream systems. Water temperature is important to the survival and growth of the species. Water temperatures of occupied habitat varies seasonally with summer temperatures ranging between 19.3 - 27°C and winter temperatures between 8.9 - 11.7°C at Araviapa Creek (Barber et al. 1970 pp. 11, 14, USFWS 2012 p. 10831). In studies conducted by the University of Arizona, the spikedace experienced 50% mortality when subjected to a water temperature of 32.1°C for 30 days and no spikedace survived for more than 12 days at = 33°C (Bonar et al. 2005 pp. 8, 29, USFWS 2012 p. 10816, 10831). Additionally, other behavioral and physiological changes were observed in spikedace, including a reduction in growth, that were subjected to temperatures = 30°C and = 10°C for any length of time (Bonar et al. 2005 pp. 8, 29, USFWS 2012 p. 10816).

Dispersal/Migration

Motility/Mobility

Larvae: Moderate

Juvenile: Low

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant

Dispersal

Larvae: Spikedace larvae disperse to stream margins where water volocity is very slow or still.

Adult: Limited by unsuitable habitat

Immigration/Emigration

Adult: No

Dispersal/Migration Narrative

Larvae: Spikedace larvae disperse to stream margins where water volocity is very slow or still.

Adult: Data on dispersal and other movements generally are not available. Spikedace have differing habitat requirements through their various life stages. Juveniles and larvae prefer habitats with low flow velocities, dispersing to higher volicities as they mature. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats. Barriers to dispersal are dams lacking a suitable fishway; high waterfall; upland habitat. For some species (e.g., slender chub), an impoundment may constitute a dispersal barrier. For others (e.g., flame chub) a stream larger than 4th order may be a barrier.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

Unknown

Number of Populations:

1 to 20 (those with good viability 1-3)

Population Size:

Unknown

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Unknown

Adaptability:

Low

Population Narrative:

Spikedace are estimated to be extirpated from approximately 90 percent of their historical range (USFWS 2012). USFWS (2012) designated critical habitat in 8 units, some of which comprised separate stream segments. These could be interpreted as representing not more than 10 locations (with respect to threats, as defined by IUCN). However, the number of occurrences or locations currently with at least good viability probably does not exceed 5. Total adult population size is unknown; abundance in the occupied habitat ranges from common to very rare (USFWS 2012). Spikedace remain limited in distribution in Aravaipa Creek, the mainstem Gila River, and the West and Middle Forks of the Gila River. Spikedace have not been detected in the Verde River since 1999, and in Eagle Creek since 1989 (Marsh 1996). Translocated populations in Spring Creek, Fossil Creek, the Blue River, and the San Francisco River show promise and, given more time to establish and recover from setbacks, may help in expanding the distribution of spikedace across a great portion of its historical range. Translocation efforts at Muleshoe Canyon, Redfield Canyon, and Bonita Creek have proven unsuccessful. Spikedace are believed to be extirpated from Mangas Creek at this time (USFWS, 2023).

Threats and Stressors

Stressor: Prolonged drought (climate change)
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: While spikedace have survived many droughts in their evolutionary histories, the present status of this species and its habitat are so degraded that the effects of the drought are more difficult for the species to withstand. In some areas of spikedace habitat, drought results in lower streamflow, and consequently warmer water temperatures beyond the species tolerance limits, and more crowded habitats with higher levels of predation and competition. In other areas, drought reduces flooding, that would normally rejuvenate habitat and tend to reduce populations of some nonnative species, which are less adapted to the large floods of southwestern streams (Minckley and Meffe 1987, pp. 94, 104; Stefferud and Rinne 1996a, p. 80). The conjunction of drought with ongoing habitat loss and alteration; increased predation, competition, and disease from nonnative species; the uncertainties associated with climate change; and the general loss of resiliency in highly altered aquatic ecosystems have had negative consequences for spikedace populations.

Stressor: Loss and degradation of habitat
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Impacts associated with roads and bridges, changes in water quality, and recreation have altered or destroyedmany of the rivers, streams, and watershed functions in the ranges of the spikedace. Activities such as groundwater pumping, surface water diversions, impoundments, dams, channelization, improperly managed livestock grazing, wildfire, agriculture, mining, road building, residential development, and recreation all contribute to riparian habitat loss and degradation of aquatic resources in Arizona and New Mexico. Changes in flow regimes are expected to continue into the foreseeable future.

Stressor: Nonnative fishes
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.

Narrative: Competition with nonnative fish species is considered a primary threat to spikedace. As with many fish in the West, spikedace lacked exposure to a wider range of species, so that they seem to lack the competitive abilities and predator defenses developed by fishes from regions where more species are present (Moyle 1986, pp. 28–31; Douglas et al. 1994, pp. 9– 10). As a result, the native western fish fauna is significantly impacted by interactions with nonnative species. The introduction of more aggressive and competitive nonnative fish has led to significant losses of loach minnow (Douglas et al. 1994, pp. 14– 17). Spikedace have been severely impacted by the presence of nonnative predators. Aquatic nonnative species have been introduced or spread into new areas through a variety of mechanisms, including intentional and accidental releases, sport stocking, aquaculture, aquarium releases, and bait-bucket release. Channel catfish, flathead catfish, and smallmouth bass appear to be the most prominent predators. In addition to threats from predation, spikedace are likely to become impacted by parasites that have been documented in the Gila River basin and that are known to adversely affect or kill fish hosts.

Recovery

Reclassification Criteria:
Downlisting Recovery Criteria 1. Remnant Populations. Maintain all 5 remnant populations of spikedace in the wild at population levels identified in Table 1 (below) with trends of recruitment and population size indices considered stable or positive over the most recent rolling 10-year period. Conduct annual monitoring to document species persistence. 2. Replicate Populations. Within each Recovery Unit, the combination of remnant (Downlisting Criterion 1 above) and replicate populations must be three or more, as detailed in Table 1 (below). Because the recovery objective is to have the species persist without continual human management intervention, that total cannot include more than one refugia population. Replicates into new locations may require stream renovation to remove nonnative species that would compete with prey on spikedace. For wild populations, conduct annual monitoring to determine species are self-sustaining, as shown by persistence and reproduction, for five consecutive years following the last stocking effort at each site (USFWS, 2019).

Recovery Priority Number: 4C

Delisting Criteria:
Spikedace will be considered for delisting when the following criteria are completed in addition to the downlisting criteria above: 1. Remnant Populations. Maintain all populations of spikedace defined in Table 1 (above). Conduct annual monitoring to determine if the population is self-sustaining, as shown by persistence and reproduction, for five consecutive years following the last stocking effort at each site. 2. Additional Replicate Populations. Within the RUs identified in Table 1 (above), replicate additional populations of spikedace into new unoccupied areas of each respective RU. Conduct annual monitoring to determine species are persisting, as shown by persistence and reproduction, for five years following each repatriation. Replicates into new locations may first require habitat management actions to remove nonnative species that would compete with prey on spikedace (USFWS, 2019).

Recovery Actions:

- Studies: 1. Updated genetic analyses to determine the status of the populations relative to one another; one study has been completed to date, and is now 20 years old (Tibbets 1993).

2. Improved knowledge of habitat use to verify the suite of characteristics most essential to suitable habitat; information gathered would allow for better habitat renovation and site selection for future reintroduction projects, enhance our ability to analyze impacts from Federal activities, and recommend optimal minimization techniques.

- Coordination: 1. Regular meetings with Tribal, private, and multi-agency partners to stay current on captive propagation, habitat restoration, monitoring, and repatriation projects. 2. Completing revision of existing recovery plan, which should include adequate downlisting/delisting criteria, finalize a captive propagation plan, and prioritize reintroduction efforts.
- Management: 1. Complete the Verde River barrier and stream renovation and species reintroduction; 2. Re-evaluate the suitability of Bonita Creek and, if deemed suitable, complete renovation at Bonita Creek and ensure appropriate measures are enacted to minimize likelihood of subsequent reinvasion by nonnative species; 3. Revisit all potential areas through critical habitat redesignation analysis to ensure that all areas needed for survival and recovery are considered; 4. Work with Freeport McMoRan, the Apache-Sitgreaves National Forests, the San Carlos Tribe, the Arizona Game and Fish Department, and the Blue and Eagle Creek watershed group to assess the likelihood of renovating Eagle Creek; 5. Enhance captive propagation efficiency and/or duplicate the Bubbling Ponds Native Fish Conservation facility to minimize impacts on source populations while allowing for increased augmentation of introduced populations; 6. Minimize the spread of nonnative fishes; 7. Continue to participate on appropriate interdisciplinary teams on water supply issues involving appropriations through water settlements and losses due to drought or climate change; 8. Complete additional stream renovations and species reintroductions, as determined by the Recovery Team; 9. Continue overseeing relevant section 7 consultations, developing minimization measures to improve or maintain habitat quality and following through on monitoring provisions and conservation measures; 10. Livestock grazing practices have been changed in many areas minimizing or eliminating impacts in most occupied spikedace streams, therefore visit those areas under new management and determine what other stressors may need to be addressed, and whether further rehabilitation is required; 11. Develop emergency procedures for protection or evacuation of spikedace from catastrophic wildfires or other events; 12. Work with parties to provide updated, relevant information on native fishes, including spikedace; 13. Continue to implement translocations and reintroductions in New Mexico, including sites such as the San Francisco River.
- Not developed; see Recovery Actions

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Many actions are occurring, as conducted by various partners engaged in spikedace management and recovery. Additional recommendations for future actions include: • If possible given current workloads, complete the genetics management plan for the species, and use this plan to guide captive propagation, repatriation, translocation, and augmentation efforts into the future; • Identify streams within the species' historical range with appropriate habitat characteristics, similar to Fossil Creek or the Blue River, where spikedace can be translocated and prioritize native species management in these streams; • Develop a second hatchery in New Mexico to facilitate recovery efforts there; • Construct additional fish barriers where appropriate to continue species repatriation, translocation and recovery efforts; • Pursue active management under the Watershed Management Plans in Arizona • Continue nonnative removal efforts at Aravaipa Creek, Little Creek, and other systems suitable for spikedace (USFWS,

2023).

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SPECIES ACCOUNT: *Menidia extensa* (Waccamaw silverside)

Species Taxonomic and Listing Information

Listing Status: Threatened; 4/8/1987; Southeast Region (R4) (USFWS, 2015)

Physical Description

This species, sometimes referred to as the “skipjack” or “glass minnow” (Davis and Louder 1969), is a long, slender, almost transparent fish with a silvery stripe along each side. There is no sexual dimorphism. Adults are about 6.5 centimeters (2.5 inches) long. The body is laterally compressed, the eyes and mouth are large, and the jaw is sharply angled upward. The scales are very small and tissue-paper thin (Hubbs and Raney 1946). There are two dorsal fins, widely separated and transparent, supported by flexible spines (Hubbs and Raney 1946, Cooper it. al. 1977) (USFWS, 1993).

Taxonomy

Freshwater derivative of M. beryllina stock; evolved rapidly and became quite distinct (Lee et al. 1980). (NatureServe, 2015)

Historical Range

The Waccamaw silverside is endemic to Lake Waccamaw in southeastern North Carolina (USFWS, 2011).

Current Range

Endemic to Lake Waccamaw, a shallow Coastal Plain lake in Columbus County, southeastern North Carolina; also occurs in a feeder stream (Big Creek), upstream to County Road 1947; common (Page and Burr 1991). During high water, has been found in Waccamaw River immediately below Lake Waccamaw Dam (NatureServe, 2015). The specimens in the Waccamaw River were likely washed over the dam during high flows and do not represent an isolated, reproducing population (Krabbenhoft et al. 2005) (USFWS, 2011).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 4/8/1987.

Legal Description

On April 8, 1987 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Menidia extensa (Waccamaw silverside) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in North Carolina (52 FR 11277-11286).

Critical Habitat Designation

The critical habitat designation for Menidia extensa includes one CHU in Columbus County, North Carolina (52 FR 11277-11286).

Unit 1 - North Carolina, Columbus County: Lake Waccamaw in its entirety to mean high water level, and Big Creek from its mouth at Lake Waccamaw upstream approximately 0.6 kilometer (0.4 mile) to where the creek is crossed by County Road 1947.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs for Menidia extensa in North Carolina are not specified but are assumed to be the following (52 FR 11277-11286):

1. Constituent elements include high quality clear open water, with a neutral pH and clean sand substrate.

Life History

Feeding Narrative

Adult: Adults and immatures are invertivores. Diet is mainly zooplankton, especially cladocerans and ostracods (Davis and Louder 1969) (NatureServe, 2015). It apparently feeds throughout the day and night, with no preference for time, and utilizes the most available zooplankton present. Stomach content analysis showed a preponderance of crustaceans, primarily Ostracoda and Cladocera (Davis and Louder 1969). Evidence indicates the species is a surface, open-water feeder (Davis and Louder 1969) (USFWS, 1993).

Reproduction Narrative

Adult: Spawns March through July (April-June, according to Matthews and Moseley 1990), with peak in late March at water temperatures of 68-72 F. Spawns in open water near shoreline, not associated with aquatic vegetation. A small percentage of the population reaches two years of age. First larvae were collected in early May (Davis and Louder 1969) (NatureServe, 2015). Although spawning has not been observed, the species spawns after its first winter (at approximately 1 year of age). The number of eggs spawned per female averages approximately 150. There is no parental care of the eggs or young, and apparently almost all adults die soon after spawning (USFWS, 1993).

Geographic or Habitat Restraints or Barriers

Adult: Dams, upland habitat, waterfalls (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Clumped (NatureServe, 2015)

Environmental Specificity

Adult: Narrow (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Usually found near surface in open water, over a dark sand bottom; not associated with aquatic vegetation. Lake Waccamaw has surface area of about 3640 ha, averages 2.3 m in depth; neutral pH. Forms large schools. Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). The lake is fed primarily by springs (groundwater) and drainages from swamps above the northeast shore (USFWS, 2011).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Low (inferred from NatureServe, 2015; see current and historical range/distribution)

Dispersal/Migration Narrative

Adult: This species is non-migratory (NatureServe, 2015).

Population Information and Trends

Population Trends:

Not available

Species Trends:

Stable (USFWS, 2011)

Number of Populations:

1 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Adaptability:

Low (inferred from USFWS, 2011)

Population Narrative:

Total adult population size is unknown but apparently quite large. This species is represented by one occurrence (location), with a range extent less than 40 square miles (NatureServe, 2015). The species status is stable; it continues to be commonly found in schools near the surface throughout Lake Waccamaw (Rohde et al. 1994; Heise and Jones 2010). The short life cycle of the fish and its dependence on the unique habitat conditions present in Lake Waccamaw make it extremely vulnerable to any change in its environment (USFWS, 2011). Shute, et al (2000) believes that the population is similar in size to their observations in 1979-1981. Heise and Jones (2010) collected Waccamaw silversides in all five of their fish sampling locations in 2009. Approximately 1,700 acres of land along the lake shore as well as the 8,934 acres of the lake itself are protected as Lake Waccamaw State Park. (USFWS, 2020)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2011)
Exposure:

Response:
Consequence:
Narrative: Nutrient loading in Lake Waccamaw has increased over the past 37 years (National Technical Information Service 1973; Lindquist and Yarbrough 1982; NCDWQ 2010). This trend, as well as the sensitive, unusual nature of this shallow lake, means that eutrophication is a possibility, and any increase in nutrient loading could precipitate water quality conditions that could threaten the species. The shoreline of Lake Waccamaw is becoming densely developed (Chris Helms, Lake Waccamaw State Park, 2010, pers. comm.; Fritz Rohde, National Marine Fisheries Service, 2010, pers. comm.). Homes and cottages cover nearly three-fourths of the shoreline while the remaining one-fourth lies within Lake Waccamaw State Park. Coincident to this development is the potential for increase in nutrient loading in the lake (Shute 1997). Nutrient loading increases the potential for wide-scale algal blooms and corresponding eutrophication (Krabbenhoft et al. 2005). There are several water quality and water quantity issues surrounding Lake Waccamaw. Fertilizers and herbicides from encroaching lawns and gardens, sedimentation from nearby logging activities, pollution from recreational boaters, and antiquated sewer and septic systems seeping waste into the lake appear to be the biggest water quality threats. In addition, several drainage ditches contribute sediment and chemical pollution (i.e., herbicides) directly to the lake during storm events. In terms of water quantity, nearby ditches have been diverting water away from the lake to irrigate loblolly pine plantations (Chris Helms, Lake Waccamaw State Park, 2010 pers. comm.). According to NCDWQ (2010), the lake was placed on the 303(d) (i.e., “impaired waterbody”) list in 2006 due to fish tissue samples that showed excessive levels of mercury. Mercury levels are a significant problem throughout the entire Lumber River Basin and is not reflective of a point source. There is an EPA National Atmospheric Deposition Program monitoring site located at the Lake Waccamaw State Park that records mercury deposition levels next to the lake. It is not known whether the mercury levels are affecting the Waccamaw silverside population (USFWS, 2011).

Stressor: Brook silverside (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: The recent invasion of the lake by the Brook silverside (Labidesthes vanhyningi (formerly L. sicculus, pending elevation) (Wayne Starnes, NC Museum of Natural Sciences, 2010, pers. comm.), is of concern. Shute et al. (2000) noted that the Brook silverside, a species previously unknown in the Waccamaw drainage was reported in this system in 1998. Habitat segregation appears to occur between the two silverside species, as Heise and Jones (2010) noted that “Waccamaw silversides were typically collected in open waters, and habitat use of the adults and juveniles do not appear to overlap with the brook silversides”. Currently, the potential for negative interaction between the two silverside species is unknown (USFWS, 2011).

Stressor: Drought (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Recent droughts have impacted the Lake, and thus the habitat for the Waccamaw silverside. The drought has decreased incoming tributary flows, thus the typical “flushing” of the lake has not occurred. This has resulted in severe algal blooms, which impacts the overall water quality of the lake (Chris Helms, Lake Waccamaw State Park, 2010, pers. comm.) (USFWS, 2011).

Stressor: Short life cycle (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: Because the Waccamaw silverside has an annual life cycle, it is susceptible to rapid extinction given reproductive failure for even a single year (USFWS, 2011).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
The recovery plan states that recovery of the Waccamaw silverside does not appear to be feasible unless other populations are found or established (USFWS, 2011).

Recovery Actions:

- Protect the existing population and essential habitat (USFWS, 1993).
- Elicit support through development and utilization of an information/education program (USFWS, 1993).
- Determine the specific habitat requirements of all life stages of the species and threats to the species' continued existence (USFWS, 1993).
- Implement management and, to the extent possible, alleviate threats to the species' existence (USFWS, 1993).
- Develop techniques for artificial holding/propagation and cryopreservation of the species (USFWS, 1993).
- Implement a bi-annual monitoring program to assess the status of the species and the water and habitat quality of Lake Waccamaw (USFWS, 1993).
- Develop clear recovery criteria and recovery objectives (USFWS, 2011).
- Determine any proposed or recent changes in land use that might affect water quality in Lake Waccamaw and work with local and state government to correct any such problems (Recovery Task 1.3) (USFWS, 2011).
- In coordination with NCWRC, develop captive propagation techniques and establish an ex situ population at the NC Zoo, NC Aquarium, hatchery or other facility (Recovery Task 3) (USFWS, 2011).
- Work with the Lake Waccamaw State Park and NC Aquarium at Fort Fisher to create an educational exhibit about the species (Recovery Task 1.3.3) (USFWS, 2011).
- Determine the number of individuals required to maintain a viable population, including a genetic study to determine the current effective population size and, from there, try to extrapolate that which would be needed to maintain the current level of variability (Recovery Task 2.4) (USFWS, 2011).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Develop clear recovery criteria and recovery objectives • Determine any proposed or recent changes in land use that might affect water quality in Lake Waccamaw and work with local and state government to correct any such problems

(Recovery Task 1.3) • In coordination with NCWRC, develop captive propagation techniques and establish an ex situ population at the NC Zoo, NC Aquarium, hatchery or other facility (Recovery Task 3) • Work with the Lake Waccamaw State Park and NC Aquarium at Fort Fisher to create an educational exhibit about the species (Recovery Task 1.3.3) • Determine the number of individuals required to maintain a viable population, including a genetic study to determine the current effective population size and, from there, try to extrapolate that which would be needed to maintain the current level of variability (Recovery Task 2.4) (USFWS, 2020)

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SPECIES ACCOUNT: *Moapa coriacea* (Moapa dace)

Species Taxonomic and Listing Information

Listing Status: Endangered; March 11, 1967.

Physical Description

The Moapa dace has a black spot at the base of the tail and small, embedded scales, which create a smooth, leathery appearance. Coloration is olive-yellow above, with indistinct blotches on the sides; the belly is white. A diffuse, golden-brown side stripe may also be present. The maximum size is approximately 12 centimeters (cm) (4.7 inches [in.]) (USFWS 1995).

Taxonomy

Among North American minnows (Family: Cyprinidae), the Moapa dace is regarded as being most closely related to the dace genera Rhinichthys (speckled dace) and Agosia (longfin dace). These three dace genera, along with the genera Gila (chub), Lepidomeda (spinedace), Meda (spikedace), and Plagopterus (woundfin), developed from a single ancestral type and are only associated with the Colorado River Basin (USFWS 1995).

Historical Range

Moapa dace are endemic to the upper Muddy River and tributary thermal spring systems in the Warm Springs area. Historically, they may have inhabited as many as 25 individual springs and up to 16 kilometers (km) (10 miles [mi.]) of stream habitat (USFWS 1995).

Current Range

The Moapa dace (Moapa coriacea) is a thermophilic minnow that exists as a relict species of the pluvial White River system in southeastern Nevada, running approximately 322 km (200 mi) from the present-day White River to the Colorado River near Lake Mead. Today, few sections of this historic channel exhibit surface flow; the springs that form the headwaters of the Muddy River, now support eight endemic aquatic taxa, including the Moapa dace. The entire range of the Moapa dace includes approximately 5.6 km (3.5 mi) of stream habitat (USFWS, 2023).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Moapa dace are omnivorous, feeding primarily on invertebrates, but also algae, vascular plants, and detritus. Moapa dace have been observed in "drift stations"—areas with vegetative cover, located in reaches of low to moderate water velocity, adjacent to depressions in the substrate—where they feed in groups. They actively feed 24 hours a day, but peak feeding occurs around dawn and dusk (USFWS 1995).

Reproduction Narrative

Adult: The reproductive strategy of the Moapa dace is oviparous. They reach sexual maturity at 1 year and are capable of reproducing year-round, with peak spawning activities in the spring. They have been documented to lay between 60 and 772 eggs, and have a high reproductive capacity (USFWS 1995). Their lifespan is approximately 4 years (USFWS 2014). They require a very narrow range of water temperatures for reproduction; therefore, sexually mature Moapa dace must migrate upstream into thermal tributaries to spawn successfully. Specifically, this species' requirements for reproduction include water temperatures of 30 to 32 °C (86 to 89.6 °F), sandy-silt substrates at depths of 15 to 19 cm (5.9 to 7.5 in.), and near-bed water velocities of 3.7 to 7.6 cm/sec (1.5 to 3.0 in,/sec.) (USFWS 1995).

Geographic or Habitat Restraints or Barriers

Adult: Water temperature, water velocity.

Spatial Arrangements of the Population

Adult: Habitat use varies among larval, juvenile, and adult life stages. Larval dace are found only in the upper reaches of tributaries, and occur most frequently in slack water. Juveniles occur throughout tributaries, and occupy habitats with increasing flow velocities as they grow. Adult dace inhabit both tributaries and the main stem Muddy River, but occur more often in the river except during spawning (USFWS 1995).

Environmental Specificity

Adult: Community with key requirements.

Tolerance Ranges/Thresholds

Adult: Moderate range for adult survival, low for spawning because the temperature range is extremely narrow.

Site Fidelity

Adult: High

Habitat Narrative

Adult: Moapa dace occupy several freshwater habitats in the Warm Springs area, including creeks, pools, riffles, and springs, as well as the main stem of the Muddy River (NatureServe 2015). They can occupy a moderate range of water quality parameters, including warm temperatures (19.5 to 33.9 °C [67.1 to 93 °F]), average to low dissolved oxygen, and variable turbidity, as well as a variety of substrates. Waters must contain abundant algae and be shaded with vegetation (NatureServe 2015). Water temperatures and velocity outside of their range act as a habitat barrier. Larval dace are found only in upper reaches of tributaries, and occur most frequently in slack water. Juveniles occur throughout tributaries, and occupy habitats within increasing flow velocities as they grow. Adult dace inhabit both tributaries and the main stem Muddy River, but occur more often in the river except during spawning. Based on the narrow distribution of the species, site fidelity is high (USFWS 1995).

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: Migratory

Dispersal

Adult: Adult Moapa dace occupy a variety of habitats in the Warm Springs area, but require thermal waters for spawning (USFWS 1995).

Immigration/Emigration

Adult: No

Dispersal/Migration Narrative

Adult: Moapa dace are moderately motile, because they occupy a wide range of habitats within their narrow distribution in the Warm Springs area. They must migrate upstream from the Muddy River into thermal tributaries to spawn successfully (USFWS 1995).

Population Information and Trends

Population Trends:

Increasing (USFWS, 2023)

Species Trends:

Increasing (USFWS, 2023)

Population Growth Rate:

Stable

Number of Populations:

One (USFWS, 2023)

Population Size:

currently < 2,000 (variable year/year) (USFWS, 2023)

Adaptability:

Low

Population Narrative:

Based on current surveys, trends show an increase in population size for the species (USFWS 2013). There are currently between 6 and 20 occurrences (NatureServe 2015), with a total population size of 1,727 individuals throughout their range (USFWS 2013). The species is moderately resilient, but representation and redundancy are low. Population growth rate appears to be stable. Based on the narrow range of the species, adaptability is low. Spatial Distribution Distribution of the entire species is restricted to a single population occurring in the headwaters of the Muddy River, Clark County, Nevada (La Rivers 1962). The Muddy River emerges from a series of small to medium-sized seeps and springs, referred to as the Muddy River Springs Area. The historic range would have included the five major spring systems and extended downstream several miles. Some report that historic range may have approximated 16 km (10 mi) of stream habitat (Ono et al. 1983). The downstream extent of the species is thermally limited as water cools moving downstream (La Rivers 1962). For the last 30 years, the length of occupied habitat is approximately 9.7 km (6 mi), extending from the headwaters to near the bridge at Warm Springs Road (Figure 2). However, the occurrence of Moapa dace in the lower mainstream river is rare at present as indicated by the biannual sampling of the BAC in 2023. Abundance The population size of Moapa dace is estimated biannually in the winter (February) and summer (August) seasons. Early surveys for this species (Scoppetone et al. 1998) found that snorkeling was an effective method to estimate population size without handling stresses associated with other methods. Surveys are conducted by stream segment from downstream to upstream to eliminate turbid conditions caused by upstream counters (Figure 3). In recent years, snorkel surveys have been conducted using trained representatives from the Service, Nevada Department of Wildlife, and the Southern Nevada Water Authority. Surveys of Moapa dace have indicated fluctuations in population size. Figure 3 shows the biannual estimates for Moapa dace from 2005 to summer 2023. Abundance appears to be strongly influenced by both habitat restoration, fish passage or lack of connectivity, and the biological interactions of predatory non-native fishes, the impacts of which depend on site-specific habitat characteristics and species-specific interactions. Although the Muddy River Springs Area is now free of nonnative blue tilapia (Oreochromis aureus), western mosquitofish (Gambusia affinis) and short-fin mollies (Poecilia sphenops) remain in the system (BAC 2023). The gradual increase in population size after 2012 (Figure 1) is suspected to correspond to the period following population expansion after blue tilapia (invasive predator) was eradicated from the system. Concurrently, significant habitat improvements were completed between 2013 and 2016 on the Warms Springs Natural Area in reach 5.5 (Figure 3). Also noteworthy is that the mainstream Muddy River and upper areas of the North and South Fork (reaches 15 and 16, respectively), at present, do not support significant numbers of Moapa dace. The upper reaches have not been recolonized since the piscicide treatments to remove blue tilapia. The larger habitat of the mainstream Muddy River (reaches 11, 12 and 13) does not support large numbers of dace but has increased in recent years. Given the historical importance of the mainstream channel to support large numbers of large dace (and associated higher fecundity typical of larger fish), understanding the causes for low abundance in these reaches remain a research priority. Instream flows are protected under a 2006 MOA between the Service and water users (Service 2006). The second criteria for downlisting specifies that “4500 adult Moapa dace are present among the five spring systems and the upper Muddy River.” At present, less than 2000 total fish are estimated (USFWS, 2023).

Threats and Stressors

Stressor: Water diversion
Exposure: Diversions of Muddy River water and water from the Warm Springs Ranch for agricultural and industrial uses.
Response: Decreased water quality and quantity.
Consequence: Elimination of species from several springs.
Narrative: Water diversion for agricultural/industrial use is a historic and current threat to the Moapa dace. Diversions may decrease water quality due to reduced flows, and may eliminate available spring habitat.

Stressor: Habitat alteration for recreational use
Exposure: Historically, known habitat was altered for recreational use of the thermal springs.
Response: Decreased habitat availability.
Consequence: Elimination of populations.

Narrative: Prior to 1979, the species was eliminated from several springs due to the springs being concreted and/or graveled, channelized, chlorinated; and to vegetation being removed to create public swimming pools.

Stressor: Nonnative fish
Exposure: Introduction of several species of nonnative fish has occurred within the ecosystem.
Response: Competition, predation, introduced fish parasites.
Consequence: Reduced size and fitness of remaining populations.
Narrative: The introduction of several species of nonnative fish and their parasites has increased stress on Moapa dace populations. Invasive introductions have increased predation, competition, and stress.

Stressor: Invasive and nonnative vegetation (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: The introduction of aquatic invasive plants has changed conditions in the Muddy River. Root masses from palm trees have choked portions of the stream and constricted outflow since the early 1980s (Service 1995). Narrowed channels speed up the flow and reduce the slower, marginal habitat required by larval and juvenile Moapa dace (Scoppetone et al. 1992). Palm trees also increase evapotranspiration and likely contribute to water loss in the system (Service 1995). Since the 1980s, the MVNWR has an ongoing program to remove palms. The distribution and number of palm trees on the Refuge and surrounding areas is vast, and given the cost associated with removal, this task will continue for many years (USFWS, 2023).

Stressor: Stochastic Events (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Since the species habitat is limited, it is susceptible to catastrophic events that may adversely modify habitat conditions. Small populations have an inherent risk of extirpation due to stochastic events. Fire and flooding are natural events that occur within Moapa dace habitat but are exacerbated by manmade factors such as extensive groves of palm trees and unnatural ignition of fires. Several catastrophic fires have occurred in recent history and nearly eliminated dace from stream segments. In 1994 a large fire nearly extirpated the Refuge Spring system (Service 1995). Another fire in 2010 has similar effects on the Warm Springs Natural Area (USFWS, 2023).

Recovery

Reclassification Criteria:
Existing instream flows and historical habitat in three of the five occupied spring systems (Apcar, Baldwin, Cardy Lamb, Muddy Spring, and Refuge) and the upper Muddy River have been protected through conservation agreements, easements, or fee title acquisitions (USFWS 1995).

4,500 adult Moapa dace are present among the five spring systems and the upper Muddy River (USFWS 1995).

The Moapa dace population comprises three or more age classes, and reproduction and recruitment are documented from three spring systems (USFWS 1995).

Recovery Priority Number: 1C

Delisting Criteria:
When all reclassification criteria have been met (USFWS 1995).

6,000 adult Moapa dace are present among the five spring systems and the upper Muddy River for 5 consecutive years (USFWS 1995).

75 percent of the historical habitat in the five spring systems and the upper Muddy River provides Moapa dace spawning, nursery, cover, and/or foraging habitat (USFWS 1995).

Nonnative fishes and parasites no longer adversely affect the long-term survival of Moapa dace (USFWS 1995).

Recovery Actions:
- Protect instream flows and historical habitat in the upper Muddy River and tributary spring systems (USFWS 1995).
- Conduct restoration/management activities (USFWS 1995).
- Monitor Moapa dace population (USFWS 1995).
- Research population health (USFWS 1995).
- Provide public information and education (USFWS 1995).
- Establish Moapa dace in refugia.
- Acquire private land as essential habitat for the Moapa dace.
- Improve habitat continuity between thermal spring systems and the Muddy River.
- Develop a conservation strategy for the Muddy River ecosystem.
- Establish a monitoring program to assess population trends and habitat conditions.

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS Over the next 5 years, mangers should focus on outstanding impediments to population growth. In general, the recovery goals identified in the 1995 Plan for the Rare Aquatic Species of the Muddy River Ecosystem are attainable. Several of the recently restored habitats near the headwaters support reliable and stable populations in similar sizes to those documented prior to invasion of blue tilapia. Ongoing discussion by the BAC in recent years revolves around increasing the geographic distribution of Moapa dace. Restored areas in the headwaters and stretches within the mainstream Muddy River have not been recolonized, while others support robust populations of Moapa dace. Recommendations for future actions include: • Research to compare the physical and biological attributes of mainstream reaches of today with those documented in the early 1990s when population sizes were highest; • Remove impediments to fish passage, especially in cases where known barriers exist between restored, high quality habitats; • Expand a program to monitor for invasive species (traditional and molecular methods) in the lower Muddy River, where future invasions of predatory fish are likely; • Develop a long-term plan to mitigate vegetation growth for stream encroachment and catastrophic fire; and • Maintain partnerships with water stakeholders to preserve and expand in-stream flows (USFWS, 2023).

Additional Threshold Information:

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USFWS (U.S. Fish and Wildlife Service). 1995. Recovery Plan for the Rare Aquatic Species of the Muddy River Ecosystem. Portland, Oregon. 60 pp.

SPECIES ACCOUNT: *Notropis albizonatus* (Palezone shiner)

Species Taxonomic and Listing Information

Listing Status: Endangered; Southeast Region (R4)

Physical Description

The palezone shiner is an extremely slender, cylindrical minnow that reaches a maximum standard length of about 60 mm. General body coloration is a light, translucent straw color. The narrow, dark mid-lateral stripe runs over the lateral-line scale row onto the silvery operculum and often encircles the snout as a discernible but dusky stripe on the upper lip and anterior snout. Extending the length of the body, just above and contrasting sharply with the mid-lateral stripe, is the “pale zone” or supralateral stripe, a broad and relatively pigmentless stripe about two scale rows in width (Warren et al. 1994).

Taxonomy

A member of the Notropis procne species group (Warren et al. 1994). Highly distinctive, with negligible differences between the allopatric populations (Starnes 1995). 1995). (NatureServe, 2015)

Historical Range

Historical and recent survey efforts suggest that the palezone shiner is absent from other areas of the Cumberland River drainage (USFWS 1997). (NatureServe, 2015)

Current Range

The Palezone Shiner is restricted to the Little South Fork system in Kentucky and the Paint Rock River system in Alabama (Figure 1, Appendix C). The species has been extirpated from Marrowbone Creek, Cumberland County, Kentucky (Cumberland River drainage); Cove Creek, Campbell County, Tennessee (Tennessee River drainage); and the Tennessee River mainstem (Guntersville Reservoir), Jackson County, Alabama (Figure 1, Appendix C). Within the Little South Fork, the species occupies a 49.0-km (30.4-mi) stream reach that extends from about the KY 167 bridge crossing in Wayne County downstream to the Freedom Church Road crossing (Freedom Church Ford) at the Wayne County / McCreary County border. Collections in July 2020 documented the species’ continued presence at three historical sites (Appendix C), with evidence of reproduction and recruitment. The species occupies about 40.5 km (25.2 mi) in the Paint Rock system, but recent surveys suggest a small population size (Shepard et al. 1997, O’Neil et al. 2013, TVA unpublished data). Stallsmith (2019, pers. comm.) completed surveys from August to October 2018 at six sites in the Paint Rock system, expanding the species’ known range by 4.7 km (2.9 mi) in the Paint Rock mainstem (downstream) and by 4.4 km (2.6 mi) in Hurricane Creek (upstream). (USFWS, 2020)

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: According to Henry et al. (1999), palezone shiners feed primarily (89 percent of identified remains) on fly larvae (Suborder Nematocera), but other aquatic organisms were observed in gut analyses (small crustaceans, roundworms, aquatic mites, diatoms, and some plant material). The species likely feeds throughout the day but is probably more active during daylight hours (Henry et al. 1999).

Reproduction Narrative

Adult: There is a paucity of information on reproduction of the palezone shiner (Warren et al. 1994). Observations by Warren and Burr (1990) indicate that males and females mature at about 35 to 40 mm standard length. Tubercles are developed on breeding males by mid-May, and peak spawning condition apparently occurs in June but may last into early July; testes are not fully developed until June and are latent by early August, concomitant with the loss or reduction of tubercles. Females captured in mid-May through late June have extended abdomens and possess large cream- to yellow-colored ova; by early August, ovaries are transparent, and most ova are small and white to translucent. These observations indicate a spawning period from late May through June and perhaps early July. Other aspects of spawning behavior are unknown.

Habitat Narrative

Adult: Palezone shiners are most commonly associated with flowing pools and runs of 3rd to 5th order upland streams that have permanent flow, clear water, and substrates composed of bedrock, cobble, pebble, and gravel mixed with clean sand (USFWS 1997). Individuals have also been observed near gravel bars that were bordered by beds of water willow, Justicia americana. The species has been found in water depths ranging from 30-76.2 cm (12-30 inches) in PRR and 30-45 cm (1.2-1.8 inches) in LSF (Shepard et al. 1997; Warren et al. 1994). Current velocities at locations of collected individuals in LSF ranged from 0.6-4.5 cm/sec (0.02-0.15 feet/sec) (Warren et al. 1994).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Population Information and Trends

Population Trends:

Stable to Increasing

Population Narrative:

The species appears to be stable to increasing within the LSF system (Jenkins 2007). Length-frequency histograms from collected individuals in LSF indicate successful recruitment (Jenkins 2007; Henry et al. 1999). Recent information from Alabama (O'Neil at al. 2013) indicate that the species continues to occupy 27 stream kilometers (16.8 miles) in the PRR system, though they occur in low numbers and are not widespread throughout the system. No current population estimates are available for the palezone shiner. However, current status trends for the palezone shiner show that extant populations of the palezone shiner are restricted to the LSF and PRR (Warren et al. 1994; Shepard et al. 1997; Jenkins 2007; O'Neil et al. 2013).

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative: The restricted range of this species makes its populations much more vulnerable to extirpation from toxic chemical spills, habitat modification, progressive degradation from land surface runoff (nonpoint-source pollutions), and natural catastrophic changes to their habitat (e.g., flood scour, drought). Populations within the LSF and PRR are vulnerable to stochastic events; a single toxic chemical spill or an extremely dry summer could have devastating effects on population numbers in both systems and could threaten the long-term viability of the species. The disjunct nature of Little South Fork and PRR populations prohibits the natural interchange of genetic material between these populations, and the small population size reduces the reservoir of genetic diversity within populations. This can lead to inbreeding depression and reduced fitness of individuals (Soule 1980; Hunter 2002). It is likely that some of the palezone shiner populations are below the effective population size required to maintain long-term genetic and population viability (Soule 1980; Hunter 2002). The disjunct nature of the two populations also makes the likelihood of recolonization of either population unlikely in the event of an extirpation event. Other threats listed in the palezone shiner recovery plan (USFWS 1997) are: 1. Water pollution from coal mining activities; 2. Loss of free-flowing stream habitat from reservoir construction and subsequent; 3. Increases in stream temperatures from removal of riparian vegetation ; and 4. Stream channelization and increased siltation associated with poor agricultural and mining practices, and deforestation of watersheds.

Recovery

Reclassification Criteria:
1. Through protection and enhancement of the existing populations, a viable population of the palezone shiner exists in the LSF and PRR.

2. Studies of the species' biological and ecological requirements have been completed, and the implementation of management strategies developed from these studies has been successful in increasing the number and range of the palezone shiner in the LSF and PRR.

3. No foreseeable threats exist that would likely threaten the survival of a significant portion of the species' range in either the LSF or PRR.

Delisting Criteria:
In addition to meeting downlisting criteria, the Palezone Shiner will be considered for delisting when all of the following criteria have been met: 1. Two (2) additional populations of the Palezone Shiner are discovered or established that exhibit stable or increasing abundance trends, as evidenced by natural recruitment, and the presence of multiple age classes. 2. One (1) population (as defined in criterion 1) must occur in the upper Cumberland River system in Kentucky and/or Tennessee and one (1) population (as defined in criterion 1) must occur in the upper Tennessee River system in Alabama and/or Tennessee (addresses Factor E). 3. Threats have been addressed and/or managed to the extent that that the species will be viable into the foreseeable future (addresses Factors A and D) (USFWS, 2019).

Recovery Actions:

- The palezone shiner is assigned a recovery priority of five, which indicates that the palezone shiner is taxonomically categorized as a species, has a high degree of threat, and low recovery potential. The species was historically known from only four rivers and/or streams. Two of these populations have been extirpated, and it is unlikely that the species can be successfully reintroduced into either of these streams due to poor water quality and habitat conditions at these sites. Therefore, unless other historical habitat can be located and repopulated or other existing populations are found, it will be difficult to protect and expand the existing populations to the point where recovery can be achieved. The recovery plan states that it may not be possible to accomplish recovery for the palezone shiner.
- Continue to conduct fish inventories (at approximate five-year intervals) and water quality investigations of the LSF and PRR basins in order to monitor the status and distribution of the species and water quality conditions in each basin.
- Conduct further fish inventories in Rock Creek and lower South Fork Cumberland River, McCreary County, Kentucky to determine the status of the species in these watersheds.
- Determine habitat preferences of juvenile and larval palezone shiners. The biology of larvae is unknown, and recruitment estimates are lacking.
- Determine the level of genetic exchange between populations and diversity within populations. Information on palezone shiner movements and genetics would provide important information on the species' long-term viability and its effective population size.
- Continue to protect, restore, and enhance habitat quality throughout the drainage.

Conservation Measures and Best Management Practices:

- USFWS. 2020. Palezone Shiner (Notropis albizonatus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Interior Region 1, North Atlantic-Appalachian Kentucky Ecological Services Field Office Frankfort, Kentucky. 30 pp. 4) Consult with agency partners and species experts to determine what biological or ecological studies are needed to better understand the species' life history and sensitivity to threats. Using this information, determine what management strategies are needed to improve the species' status in the Little South Fork and Paint Rock systems. 5) Determine the level of genetic exchange (if any) between populations and diversity within populations (population genetics). Information on Palezone Shiner movements and genetics would provide important information on the species' long-term viability and its effective population size. 6) Continue to protect, restore, and enhance habitat quality throughout the Little South Fork and Paint Rock systems. Federal, state, and private parties should continue to work cooperatively (through Farm Bill programs, Partners for Fish and Wildlife projects, Kentucky Wild Rivers Program, etc.) to restore and protect habitats for the species. 7) Organize and assemble a group of agency partners and other species experts to evaluate the possibility of reintroducing the species into other Cumberland and Tennessee River tributaries. (USFWS, 2020)

References

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SPECIES ACCOUNT: *Notropis buccula* (Smalleye Shiner)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/04/2014; Southwest Region (Region 2) (USFWS, 2016a)

Physical Description

The sharpnose and smalleye shiners are small (~2 in. overall length) minnows native to Texas belonging to the Cyprinidae family. The sharpnose shiner is typically olive colored on top and silver-white with a faint stripe on the sides. The smalleye shiner, when compared to the sharpnose shiner, has lighter white scales (USFWS, 2016b).

Taxonomy

Originally described as subspecies of N. bairdi; subsequently has been accorded full species status (Lee et al. 1980; Robins et al. 1991; Page and Burr 1991, 2011). (NatureServe, 2015)

Historical Range

The smalleye shiner historically occurred throughout the Brazos River proper, the Double Mountain and Salt Forks of the Upper Brazos River drainage, and in the Lampasas River, a tributary of the Brazos (Moss and Mayes, 1993). (NatureServe, 2015)

Current Range

Smalleye shiners are small minnows restricted to the contiguous river segments of the upper Brazos River basin in north-central Texas at the time of their listing. (USFWS, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/4/2014.

Legal Description

On August 4, 2014, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Notropis buccula (Smalleye shiner) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes six critical habitat units (CHUs) in Texas (79 FR 45242-45271).

Critical Habitat Designation

The critical habitat designation for Notropis buccula includes six CHUs in Baylor, Crosby, Fisher, Garza, Haskell, Kent, King, Knox, Stonewall, Throckmorton, and Young Counties, Texas (79 FR 45242-45271).

Subunit 1: Brazos River Main Stem from approximately 15 river km (9.3 miles) upstream of the eastern border of Young County where it intersects the upper portion of Possum Kingdom Lake (32.974302, ¥98.509880) upstream to the confluence of the Double Mountain Fork of the Brazos River and the Salt Fork of the Brazos River where they form the Brazos River main stem (33.268404, ¥100.010209); Baylor, King, Knox, Stonewall, Throckmorton, and Young Counties, Texas. Map of Upper Brazos River Main Stem Subunit is provided at paragraph (7) of the entry for the sharpnose shiner in this paragraph (e).

Subunit 2: Salt Fork of the Brazos River from its confluence with the Double Mountain Fork of the Brazos River (33.268404, ¥100.010209) upstream to the McDonald Road crossing (33.356258, ¥101.345890); Garza, Kent, and Stonewall Counties, Texas. Map of Salt Fork of the Brazos River Subunit is provided at paragraph (8) of the entry for the sharpnose shiner in this paragraph (e).

Subunit 3: White River from its confluence with the Salt Fork of the Brazos River (33.241172, ¥100.936181) upstream to the White River Lake impoundment (33.457240, ¥101.084546); Crosby, Garza, and Kent Counties, Texas. Map of White River Subunit is provided at paragraph (9) of the entry for the sharpnose shiner in this paragraph (e).

Subunit 4: Double Mountain Fork of the Brazos River from its confluence with the Salt Fork of the Brazos River (33.268404, ¥100.010209) upstream to the confluence of the South Fork Double Mountain Fork of the Brazos River and the North Fork Double Mountain Fork of the Brazos River where they form the Double Mountain Fork of the Brazos River (33.100269, ¥100.999803); Fisher, Haskell, Kent, and Stonewall Counties, Texas. Map of Double Mountain Fork of the Brazos River Subunit is provided at paragraph (10) of the entry for the sharpnose shiner in this paragraph (e).

Subunit 5: North Fork Double Mountain Fork of the Brazos River from its confluence with the South Fork Double Mountain Fork of the Brazos River (33.100269, ¥100.999803) upstream to the earthen impoundment near Janes-Prentice Lake (33.431515, ¥101.479610); Crosby, Garza, and Kent Counties, Texas. Map of North Fork Double Mountain Fork of the Brazos River Subunit is provided at paragraph (11) of the entry for the sharpnose shiner in this paragraph (e).

Subunit 6: South Fork Double Mountain Fork of the Brazos River from its confluence with the North Fork Double Mountain Fork of the Brazos River (33.100269, ¥100.999803) upstream to the John T. Montford Dam of Lake Alan Henry (33.065008, ¥101.039780); Garza and Kent Counties, Texas. Map of South Fork Double Mountain Fork of the Brazos River Subunit is provided at paragraph (12) of the entry for the sharpnose shiner in this paragraph (e).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Notropis buccula critical habitat consists of four components in Texas (79 FR 45242-45271):

(i) Unobstructed, sandy-bottomed river segments greater than 275 kilometers (171 miles) in length.

(ii) Flowing water of greater than 6.43 cubic meters per second (m3s¥1) (227 cubic feet per second (cfs)) averaged over the shiner spawning season (April through September).

(iii) Water of sufficient quality to support survival and reproduction, characterized by: (A) Temperatures generally less than 40.6 °C (105.1 °F); (B) Dissolved oxygen concentrations generally greater than 2.11 milligrams per liter (mg/L); (C) Salinities generally less than 18 parts per thousand (ppt) (30 millisiemens per centimeter (mS/cm)); and (D) Sufficiently low petroleum and other pollutant concentrations such that mortality does not occur.

(iv) Native riparian vegetation capable of maintaining river water quality, providing a terrestrial prey base, and maintaining a healthy riparian ecosystem.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features that are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of these species may require special management considerations or protection to reduce the following threats: Habitat loss and modification from fragmentation of river segments; alteration to natural flow regimes by impoundment, groundwater withdrawal, and drought; water quality degradation; and invasive saltcedar encroachment. River fragmentation decreases the unobstructed river length required for successful reproduction in these species. Impoundments, groundwater withdrawal, saltcedar encroachment, and drought have the potential to reduce river flow below the minimum requirement to keep the eggs and larvae of these species afloat and ultimately for sustainment of sharpnose and smalleye shiner populations. Water quality degradation resulting from pollution sources; lack of flows maintaining adequate temperatures, oxygen concentrations, and salinities; and the destruction of adjacent riparian vegetation's run-off filtering abilities may result in water quality parameters beyond which sharpnose and smalleye shiners are capable of surviving. As such, the features essential to the conservation of these species may require special management from these threats. For sharpnose shiners and smalleye shiners, special management considerations or protection may be needed to address threats. Management activities that could ameliorate threats include, but are not limited to: (1) Removing or modifying existing minor fish barriers to allow fish passage; (2) managing existing reservoirs to allow sufficient river flow to support shiner reproduction and population growth; (3) protecting groundwater, surface water, and spring flow quantity; (4) protecting water quality by implementing comprehensive programs to control and reduce point sources and non-point sources of pollution; and (5) protecting and managing native riparian vegetation. A more complete discussion of the threats to the sharpnose shiner and smalleye shiner and their habitats can be found in the March 2014 SSA Report (Service 2014, Chapter 3).

Life History

Feeding Narrative

Juvenile: Diet consists mainly of aquatic insects, dominated by dipterans; sand/silt in gut suggests foraging among substrate (Marks et al. 2001). (NatureServe, 2015)

Adult: Diet consists mainly of aquatic insects, dominated by dipterans; sand/silt in gut suggests foraging among substrate (Marks et al. 2001). Shiners are generalist feeders and have a maximum lifespan of less than three years. (NatureServe, 2015)

Reproduction Narrative

Adult: Shiners are generalist feeders and have a maximum lifespan of less than three years. However, it is believed most individuals survive only through one reproductive season, which generally occurs from April through September. Both species broadcast spawn eggs and sperm into open water asynchronously (fish not spawning at the same time) during periods of low flow and synchronously (many fish spawning at the same time) during periods of elevated streamflow from April through September (Durham 2007, p. 24; Durham and Wilde 2008, entire; Durham and Wilde 2009a, p. 26). Based on studies of similar species, their eggs are semi-buoyant and remain suspended one or two days in flowing water as they develop into larvae (Platania and Altenbach 1998, p. 565; Moore 1944, p. 211). Similarly, larval fish remain suspended in the flowing water column an additional two to three days as they develop into free-swimming juvenile fish (Moore 1944, pp. 211–212; Perkin and Gido 2011, p. 372). In the absence of sufficient water velocities, suspended eggs and larvae sink into the substrate where the majority likely die (Platania and Altenbach 1998, p. 565; Dudley and Platania 2007, p. 2083). The reproductive strategy of these species makes them particularly vulnerable to changes in the natural conditions of occupied habitat. Given their short lifespans, most sharpnose and smalleye shiners survive through only one reproductive season (Durham 2007, p. 27). (USFWS, 2015)

Geographic or Habitat Restraints or Barriers

Juvenile: Population dynamics modeling estimates a mean summer water discharge of approximately 2.61 m3s-1 (92 cfs) is necessary to sustain populations of sharpnose shiners (Durham 2007, p. 110), while a higher mean discharge of approximately 6.43 m3s-1 (227 cfs) is necessary for smalleye shiners (Durham and Wilde 2009b, p. 670). (USFWS, 2015)

Adult: Population dynamics modeling estimates a mean summer water discharge of approximately 2.61 m3s-1 (92 cfs) is necessary to sustain populations of sharpnose shiners (Durham 2007, p. 110), while a higher mean discharge of approximately 6.43 m3s-1 (227 cfs) is necessary for smalleye shiners (Durham and Wilde 2009b, p. 670). (USFWS, 2015)

Environmental Specificity

Juvenile: Moderate (USFWS, 2015)

Adult: Moderate (USFWS, 2015)

Habitat Narrative

Juvenile: The best available science suggests the primary needs of sharpnose and smalleye populations include unobstructed, wide, flat-bottom, flowing river segments of greater than 275 km (171 mi) in length to support development of their early life history stages. (USFWS, 2015)

Adult: Habitat includes sandy, turbid channels of small to medium rivers (Page and Burr 2011). Smalleye shiners require habitats almost identical to those of several other obligate riverine fishes native to Texas prairie streams (e.g., N. oxyrhynchus). Preferred habitat includes fairly shallow water (38 to 82 cm (15 to 32 in) in depth) in broad, open sandy channels with a moderate current (Moss and Mayes, 1993). Ostrand (2000) found abiotic factors associated with smalleye shiner habitat to include specific conductance 0.20 m/s)(0.65 feet/s) and high turbidity (> 41 NTU). Within their preferred habitat, smalleye shiners are most often found using the center of the channel, avoiding the shallow depth and slow velocity of the stream edges (Moss and Mayes, 1993). Population dynamics modeling estimates a mean summer water discharge of approximately 6.43 m3s-1 (227 cfs) is necessary for smalleye shiners (Durham and Wilde 2009b, p. 670). The best available science suggests the primary needs of smalleye populations include unobstructed, wide, flat-bottom, flowing river segments of greater than 275 km (171 mi) in length to support development of their early life history stages. (USFWS, 2015; NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: High (USFWS, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Not available.

Population Information and Trends

Population Trends:

Long-term trends suggest a decline of 50-70%, whereas short-term trends indicate a relatively stable population (NatureServe, 2015)

Resiliency:

Over longer terms greater than a few years, both species have naturally limited resiliency because their life span is usually 2 years or less. Therefore, impoundments and other stressors (such as groundwater withdrawals) affect the flow regime to the extent that the minimum streamflows necessary for successful reproduction and population growth in these species may not be maintained. As a result, any stressors in the upper Brazos River basin precluding successful reproduction that persist over two successive spawning seasons will not only affect individuals, but would likely lead to complete population extirpation. Since there is only one extant viable population remaining for both smalleye and sharpnose shiner, this would also result in species extinction. The potential for this kind of extinction event is heightened by climate change, which has increased the probability of severe droughts in this region. The resiliency of these species (the ability to withstand randomly occurring events of varying magnitude and duration) is limited because fish barriers restrict their ability to migrate from drought conditions and recolonize river segments upon return of favorable conditions (USFWS, 2014).

Representation:

Sharpnose and smalleye shiners lack the representation (the ability of to adapt to changing environmental conditions) necessary to overcome the impacts of habitat fragmentation and loss of river flow because it would likely require adapting their reproductive strategy. The evolution of a different reproductive strategy (away from broadcast spawning) or the extensive adaption of their existing strategy (e.g., by increasing egg/larval development rate) would not be expected to occur within a time period rapid enough to avoid being overcome by their threats (USFWS, 2014).

Redundancy:

Currently sharpnose and smalleye shiners are each essentially restricted to single populations in the upper Brazos River upstream of Possum Kingdom Lake, due primarily to habitat fragmentation and flow regime alteration in other river segments where they historically occurred but have been extirpated. Although a small number of fish were released into the lower Brazos River in 2012, these populations are likely either functionally or completely extirpated. Due to the existence of only a single population of each species in the upper Brazos River basin, all of the potential effects to this population also serve to affect the species as a whole and place the entire species at risk of extinction. Therefore, both the sharpnose and smalleye shiner currently have no redundancy (i.e., multiple populations) by which to survive a catastrophic event in the upper Brazos River basin. Any future event or action that extirpates the populations in the upper Brazos River basin would result in the extinction of the species. Future events similar to the severe drought conditions in 2011 that resulted in a complete lack of successful reproductive effort and juvenile recruitment in both species (Wilde 2012b, pers. comm.), may expose the entire range of both species to risk of complete loss. Given these species generally only survive through two reproductive seasons, back-to-back severe drought years could result in their extinction from inadequate flows without human intervention (USFWS, 2014).

Number of Populations:

1 (USFWS, 2015)

Population Size:

Unknown but estimated between 10,000 to >1,000,000 individuals (NatureServe, 2015)

Population Narrative:

Total adult population size in unknown but exceeds 10,000. With only one isolated population of each species remaining, these species have no redundancy, reduced resiliency due to the inability to disperse downstream, and limited representation. Therefore, these species are in danger of extinction from only one adverse event (such as lack of river flow for two consecutive years). The severe range reduction and isolation of these species to a single population in the upper Brazos River reduces the likelihood of their survival, which is exacerbated by the ongoing and intensifying effects of river fragmentation, climate change induced drought, saltcedar encroachment, water quality degradation, and commercial bait harvesting. (NatureServe, 2015)

Threats and Stressors

Stressor: River fragmentation (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: The two primary factors affecting the current and future conditions of these shiners are river fragmentation by impoundments and alterations of the natural streamflow regime (by impoundments, drought, groundwater withdrawal, and saltcedar encroachment). (USFWS, 2015)

Stressor: Resevoir development (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Reservoir development within the Brazos River Basin is largely responsible for the modification of habitat in the river that has rendered major portions unsuitable for the sharpnose shiner. The three major impoundments of the Brazos River proper have apparently extirpated the sharpnose shiner from the middle Brazos region and reduced it to relict

populations within the lower portion of the river. Proposed reservoir development in the upper Brazos region is a significant threat to the extant populations. While only one reservoir is currently permitted (Post Reservoir) in the upper Brazos region, others are included in the Texas State Water Plan as a potential source to meet the demand for water through the year 2060. (NatureServe, 2015)

Stressor: Mining, industrial and municipal discharge, cattle feedlot operations (CAFOs), desalination, sedimentation, and saltcedar (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Additional substantial threats to the sharpnose shiner are in-stream sand and gravel mining, industrial and municipal discharges, CAFOs, desalination, excessive sedimentation, and the spread of invasive saltcedar. The effect of saltcedar within the upper Brazos region threatens the existing sharpnose shiner habitat. Saltcedar encroachment in the upper Brazos and tributaries is likely an indirect result of impoundment of the river. Desalination is a potential future threat in the upper Brazos River Basin. In-stream sand and gravel mining, excessive sedimentation, and industrial and municipal discharges coupled with the effect of impoundments, reduce the likelihood of the Brazos River sustaining viable populations of the sharpnose shiner downstream of Possum Kingdom Reservoir. These threats combined with the substantial reduction in historic range due to anthropogenic factors justify the candidate status of the sharpnose shiner. (NatureServe, 2015)

Stressor: Habitat loss (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Significant reduction of the amount of suitable habitat reduces carrying capacity for remaining populations and reduces habitat available for successful reproduction. (USFWS, 2015)

Stressor: Reduction/alteration of stream flow (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Reduction/Alteration of stream flow – alterations in the flow regime can negatively affect shiner survivability and reproduction. Sources of reduced/altered stream flow – impoundments, drought, groundwater withdrawal, saltcedar encroachment, in-channel projects that affect channel morphology.

Stressor: Water quality degradation (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Significant reduction of water quality results in mortality of individuals and has the potential to affect these shiners at the population and species level during periods of drought and range restriction. Point source pollution – pollution results in mortality of fish and may have sub-lethal affects (although this requires further examination). Pollution has the potential to affect these shiners at the population and species level during periods of drought and range

restriction. Toxic golden alga blooms – toxic golden alga blooms result in mortality of fish and have the potential to affect these shiners at the population and species level during periods of drought and range restriction. (USFWS, 2015)

Stressor: Commercial bait harvesting (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: The removal of individuals from the wild to be sold as bait reduces the number of fish in the remaining populations of these species and has the potential to affect these shiners at the population and species level during periods of drought and range restriction. (USFWS, 2015)

Recovery

Reclassification Criteria:
Reclassification criteria are not available.

Delisting Criteria:
Delisting criteria are not available.

Recovery Actions:

- Establish partnerships to manage and control saltcedar encroachment along the riparian corridor of occupied areas of the upper Brazos River basin. (USFWS, 2015)
- Work with the Service's Fisheries Program, TPWD, and other knowledgeable entities to determine what types of road crossings are best designed to allow for water and fish passage and are stable in the arid prairie stream environment. (USFWS, 2015)
- Identify captive propagation requirements and develop a protocol for large-scale captive breeding. (USFWS, 2015)
- Work with TPWD and the scientific community to develop a protocol for the release of captive bred individuals into occupied and historically occupied reaches for research and monitoring purposes and to provide population redundancy (even if just temporarily due to habitat unsuitability). (USFWS, 2015)
- Work with stakeholders to determine the source of pollution discharges negatively affecting shiners and to take steps to avoid and minimize future surface water contamination. (USFWS, 2015)
- Work with stakeholders to remove existing fish migration barriers (including impoundments) if they are no longer useful or in service. (USFWS, 2015)
- Work with stakeholders to implement water release strategies to aid fish reproduction during the spawning season. (USFWS, 2015)
- Work with stakeholders to implement groundwater and surface water conservation strategies in the upper Brazos River basin to maximize surface water flows. (USFWS, 2015)
- Evaluate the causes of golden alga blooms, their extent, and impacts to shiners in the upper Brazos River basin. (USFWS, 2015)
- Refine estimates of required stream length and required minimum stream flow for reproductive purposes. (USFWS, 2015)
- Conservation measures are not available.

- 1.0 Ensure adequate stream flows 1.1.1 Obtain future projected municipal water demands from additional sources. 1.1.2 Implement water-efficient technologies to reduce groundwater withdrawals. 1.2.1 Understand how water resource development in the Upper Brazos River basin quantitatively affects spawning flows needed for reproductive success. 1.3.1 Understand how water resource development in the Upper Brazos River basin quantitatively affects spawning flows needed for reproductive success. 2.0 Restore and preserve natural river morphology 2.1.1 Improve fish migration and distribution. 2.1.2 Continue and expand efforts to treat salt cedar (Tamarix sp.) throughout the upper Brazos River basin with an emphasis on treatment efforts in the headwaters and tributaries of the Double Mountain and Salt Forks to reduce downstream spread. 3.0 Maintain current populations of both species 3.1.1 Determine minimum viable population (MVP) for both species. 3.2.1 Monitor populations within each management unit to determine if MVP levels are met or exceeded in each recovery unit. 3.3.1 Re-evaluate and refine stream length and flow requirements for successful recruitment. 3.4.1 Investigate population genetics; including overall genetic diversity between and among management units and inbreeding coefficients. 3.5.1 Develop and implement public outreach and monitoring programs to remediate the presence of non-native/invasive aquatic species (e.g., gulf killifish) in the upper Brazos River basin. 4.0 Establish captive breeding program 4.2.1 Determine and procure facilities, equipment and personnel necessary to house and operate captive breeding program. 4.2.2 Collect brood stock for captive population. 4.3.1 Develop and implement a reintroduction plan. 4.3.2 Monitor all augmentation and reintroduction efforts to determine their effectiveness, identify problems, and improve methods. 5.0 Ensure water quality 5.1.1 Research physical and chemical tolerances on all life stages (egg, larval, juvenile, adult) of smalleye and sharpnose shiners. 5.1.2 Collaborate with stakeholders to maintain contaminant concentrations below thresholds that cause toxicity to shiners or their prey in order to achieve recovery 5.2.1 Investigate options for additional treatments to municipal discharges prior to release into Critical Habitat for the enhancement of water quality. 5.2.2 Work with stakeholders to enhance avoidance measures that reduce or eliminate the occurrence of hazardous materials within Critical Habitat. 5.3.1 Discuss and implement, with stakeholders, the identification of problematic outfalls discharging into designated Critical Habitat. Table 4 – current outfall locations. (USFWS, 2022)
- Recovery Priority Number: 5C

Conservation Measures and Best Management Practices:

- Scenario 1 – Upper Brazos River Basin Restoration Under this scenario, groundwater extraction and climatic conditions influencing the sharpnose shiner population continue at current rates. These effects are already occurring, resulting in reduced streamflow throughout the upper Brazos River basin since the 1940s based on USGS streamflow data (source: https://waterdata.usgs.gov). To offset these sources of stream flow loss, targeted restoration actions implemented throughout the upper Brazos River basin would be necessary. Restoration actions would include the following: 1) removal of invasive species (e.g., saltcedar); 2) restoration of native stream bank plant communities; 3) protection of water quality, outreach to stakeholders, and enhanced TPDES permit review for proposed wastewater discharges to the upper Brazos River; 4) water release strategies to aid fish reproduction/recruitment during the spawning season; 5) restoration of fish passage upstream of Possum Kingdom Reservoir through removal of barriers; and 6) implementation of groundwater and surface water management strategies in the upper Brazos River basin to provide adequate surface water flows.

- Upper Brazos River Basin Restoration Under this scenario, groundwater extraction and climatic conditions influencing the smalleye shiner population continue at current rates. These effects are already occurring, resulting in reduced streamflow throughout the upper Brazos River basin since the 1940s based on USGS streamflow data (source: https://waterdata.usgs.gov). To offset these sources of stream flow loss, targeted restoration actions implemented throughout the upper Brazos River basin would be necessary. Working with stakeholders to develop and implement conservation actions throughout the upper Brazos River basin is vital. Restoration actions would include the following: 1) removal of invasive species (e.g., saltcedar); 2) restoration of native stream bank plant communities; 3) protection of water quality, outreach to stakeholders, and enhanced TPDES permit review for proposed wastewater discharges to the upper Brazos River; 4) water release strategies to aid fish reproduction during the spawning season; 5) restoration of fish passage upstream of Possum Kingdom Lake through removal of barriers; and 6) implementation of groundwater and surface water management strategies in the upper Brazos River basin to provide adequate surface water flows (see Figure 12 for map of Scenario 1). (USFWS, 2018)
- RECOMMENDATIONS FOR FUTURE ACTIONS Based on the threats evaluated and reduced range and reproductive strategy of these species, the SSA Report provides a chapter on conservation opportunities. These opportunities are summarized here: Improve redundancy and resiliency – Both species exist in only a single suitable river segment (the upper Brazos River) within the historical distribution. Redundancy may need to be addressed through a number of alternative means. Three possible means of increasing redundancy in these species are (1) a captive propagation and/or refugia program to ensure that the species are not lost due to catastrophic loss of their only populations; (2) reintroducing these species within their historical ranges and monitoring to determine their success and if minimum requirements have been correctly assessed; and (3) removal of existing fish barriers and restoration of the Brazos River, where feasible and appropriate, to provide additional river length and suitable stream flow in which sharpnose and smalleye shiners could seek refuge from severe droughts and other catastrophic events. Minimize impacts from impoundments - Despite planning and managing to accommodate the needs of sharpnose and smalleye shiners to the greatest extent possible, future reservoirs within the upper Brazos River basin will negatively impact these species. Depending on the location, design, and management of future reservoirs within the upper Brazos River basin, expected impacts would include at least one or more of the following: decreased water volume in occupied sections of the river, fragmentation or shortening of occupied river segments, changes in water quality, conversion of occupied riverine habitat to lentic habitat, alteration of river channel substrate and sediment transport, altered hydraulic habitat, or alteration of the natural flow regime. Although siting, design, and management of future reservoirs in the upper Brazos River basin could be realized in a way that may reduce adverse impacts to sharpnose and smalleye shiners, the restricted range and current status of these species makes them vulnerable to even slight changes to their remaining occupied habitat. Minimizing impacts could include: 1) adopting rigorous water conservation strategies; 2) implementing water releases from new and existing reservoirs that provide a minimum mean discharge exceeding 227 cubic feet/second in occupied downstream habitat during the spawning season (April – Sept); 3) adopting flow recommendations from the Brazos River Basin and Bay Expert Science Team Report (BBEST 2012); and 4) designing future impoundments to avoid releasing hypolimnetic water that is not representative of the upstream water. Minimize impacts from saltcedar encroachment - Saltcedar control efforts should be concentrated on dense stands that can be replaced by native vegetation with a lower leaf area—potentially including native forbs, grasses, and cottonwood trees—to maximize the potential for water salvage without eliminating important riparian vegetation communities (Shafroth et al. 2005, p. 240). The salvage of any groundwater or surface water runoff that can elevate streamflow within occupied shiner habitat would benefit these

species by supporting necessary flows for survival and successful reproduction. Chemical control of saltcedar is typically performed using imazapyr-based compounds, which are unlikely to be toxic to fish or aquatic invertebrates (USEPA 2006, pp. 17– 18; BASF 2012a, p. 2; BASF 2012b, p. 2). Implement general water conservation strategies - Improvements to agricultural, municipal, and industrial water use efficiency would decrease water demand and put less pressure on the already strained surface and groundwater resources of the upper Brazos River basin. These conservation measures (including but not limited to the use of high-efficiency household appliances and fixtures, optimization of commercial and industrial water uses, and improved irrigation efficiencies for agriculture) could reduce the need for additional reservoir development, increase groundwater contribution to streamflow, and allow existing reservoirs to release more stormwater runoff than occurs currently. These benefits from general water conservation would likely increase streamflow within occupied sharpnose and smalleye shiner habitat, improving their likelihood for survival and successful reproduction. Conserve native vegetation adjacent to occupied habitat - Riparian vegetation adjacent to riverine habitat filters surface water runoff and is important in maintaining instream water quality. The ability of riparian buffers to filter surface runoff is largely dependent on vegetation density, type, and slope, with dense, grassy vegetation and gentle slopes facilitating filtration. Due to a lack of dense, grassy vegetation throughout much of the designated critical habitat, a 30-m (98-ft) buffer may be most appropriate to maintain proper runoff filtration (Fischer and Fischenich 2000, p. 8). Conservation of native riparian vegetation along the banks of occupied sharpnose and smalleye shiner river segments is not generally expected to negatively impact farming or ranching activities, nor would it require restricting landowner access to these buffer areas. Allowing cattle access to the river might help remove vegetation that would otherwise have been removed by seasonal floods that are now reduced by upstream impoundments, thereby reducing the likelihood occupied river segments will become further channelized by encroaching vegetation. Regardless, there is no scientific evidence suggesting cattle access to occupied river segments or the riparian buffers is currently a threat to either sharpnose or smalleye shiners. (USFWS, 2021)

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SPECIES ACCOUNT: *Notropis cahabae* (Cahaba shiner)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/25/1990; Southeast Region (R4) (USFWS, 2015)

Physical Description

This species is a small, delicate-bodied, silvery-colored shiner about 2.5 inches (6.35 centimeters) long with a peach-colored narrow stripe over the dark lateral stripe. The Cahaba shiner's lateral stripe does not expand before the caudal spot, it has no predorsal dark blotch, the dorsal caudal peduncle scales are uniformly dark and pigmented, and predorsal scales are broadly outlined and diffuse (Mayden and Kuhajda 1989) (USFWS, 1992).

Taxonomy

See Mayden and Kuhajada (1989) for original description. Related to N. volucellus. (NatureServe, 2015)

Historical Range

Historically known from 122-km section of Cahaba River from about 5 km northeast of Heiberger in Perry County to Highway 52 bridge near Helena in Shelby County. (NatureServe, 2015)

Current Range

Range includes the Cahaba River and Locust Fork of Black Warrior River, Alabama, primarily above the Fall Line. Presently known range in Cahaba River is about 96 km from near Heiberger north to about 6 km above Booth Ford in Shelby County; most of population is confined within a 24-km stretch of this area; found in Locust Fork in 1998 (Boschung and Mayden 2004, Page and Burr 2011). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: It probably requires a river with sufficient small crustaceans, insect larvae, and algae for food, similar to its close relatives (Gilbert and Burgess 1980) (USFWS, 1992).

Reproduction Narrative

Adult: Spawns from mid-May through early July (peak in June) (Mettee et al. 1996) (NatureServe, 2015).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Habitat Narrative

Adult: Habitat includes flowing pools, usually over sand or gravel, in the main channel of medium-sized rivers (Page and Burr 2011); moves into lower reaches of small tributaries during flood events; occasionally found at the heads of pools and in shallow gravel riffles; has been observed in shallow water flowing through beds of emergent vegetation (Justicia) (Mettee et al. 1996). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). The species is generally found in relatively clear, well oxygenated water (USFWS, 1992).

Dispersal/Migration

Motility/Mobility

Adult: Not available

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Not available

Dispersal/Migration Narrative

Adult: This species is non-migratory. Data on dispersal and other movements generally are not available (NatureServe, 2015).

Population Information and Trends

Population Trends:

Decline of 10-30% (NatureServe, 2015)

Species Trends:

< 30% decline (NatureServe, 2015)

Number of Populations:

1 - 20 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

Extent of occurrence and area of occupancy have declined. This species has experienced a long-term decline of 10-30%. Total adult population size is unknown. This species is represented by only a few or perhaps several distinct occurrences. The Cahaba River and Locust Fork could be regarded as only two locations (as defined by IUCN, with respect to threats). The short-term species trend is a decline of <30% to relatively stable. The range extent is 400 - 2,000 square miles (NatureServe, 2015). The Cahaba shiner can be found in the Cahaba River and Locust Fork watersheds near the City of Birmingham, Alabama. The species' range at the time of listing in 1990 included 96 km (60 mi) of the Cahaba River watershed. In 1999, the species' range was more than doubled with the discovery of the Locust Fork population which added 118 km (73 mi) of the Locust Fork of the Black Warrior River and 8 km (5 mi) in Blackburn Fork, a tributary to the Locust Fork (Kuhajda and Shepard 2004). Since the latest 5-year status review in 2016, collection efforts have resulted in the capture of the Cahaba shiner in several known and one new location(s) within both the Cahaba River (Alabama River drainage) and Locust Fork (Black Warrior/Tombigbee River drainage). In 2019 a new record for the Cahaba shiner was discovered in lower Turkey Creek, approximately 0.25 miles upstream of its confluence with the Locust Fork (USFWS, Kuhajda 2019). In 2022, additional surveying by the USFWS discovered numerous specimens in both the Locust Fork and Cahaba River, with larger numbers found in the Locust Fork. The number of Cahaba shiner observed during collection efforts from 2016- 2022 are below in Table 1. Based on survey results, the Cahaba shiner population appears to be stable in the Locust Fork, however low collection numbers within the Cahaba River suggests the species continues to be very rare in this watershed (USFWS, 2022).

Threats and Stressors

Stressor: Climate change (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: "Climate change has the potential to increase the vulnerability of the Cahaba shiner to random catastrophic events. Climate change is expected to result in increased frequency and duration of droughts and the strength of storms. Climate change could intensify or increase the frequency of drought events (USFWS, 2016). "

Stressor: Genetic considerations (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: The Cahaba shiner is restricted in range and population size and its populations are considered "Evolutionary Significant Units" by Kuhajda (Kuhajda et al. 2001). Average genetic divergence (p-distance) between the Cahaba River and the Locust Fork populations is three times that of within the same population divergence. This indicates that the species is more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression, decreasing their ability to adapt to environmental changes, and reducing the fitness of individuals. Isolation of the species makes natural repopulation following localized extirpations virtually impossible without human intervention (USFWS, 2016).

Stressor: Habitat destruction and modification (USFWS, 1992, 2016)
Exposure:
Response:
Consequence:

Narrative: The major threat is water quality degradation from wastewater effluents, methane gas drilling operations, and sedimentation (USFWS, 1992). Siltation (sedimentation) in stormwater runoff from urbanized areas and eutrophication from nutrient loading by municipal wastewater and nonpoint sources are the main causes of water quality degradation in most river systems. Sedimentation is intensified by silviculture, livestock production, and by re-establishing coal mines and their infrastructure. Increased urbanization leads to declining water quality in streams and fish assemblages. Runoff from coal surface mining generates pollution through acidification, increased mineralization, and sediment loading. Due to high demand for coal, watersheds within the Cahaba and Plateau Coal Fields of the Warrior Coal Basin have historically been partially impaired by means of degraded water quality caused by heavy metals, acids, and sediment run off from active and abandoned coal mines. Long term impacts and secondary development from the Northern Beltline project includes the conversion of land from its current use (mostly undeveloped) to paved surface for the width of the roadway and the vegetation cleared out of the project's right of way boundary. This change in land use typically results in accelerated storm water runoff into streams. Depending on the amount of land that was converted from a natural condition to a paved surface within the drainage area of a stream, the stream may experience increased water velocities that result in streambed and bank erosion and degradation, sediment and pollutant loading, and other morphological changes runoff (USFWS, 2016).

Stressor: Stochastic events (USFWS, 2016)
Exposure:
Response:
Consequence:
Narrative: The Cahaba shiner occurs in two distinct and non-connecting watersheds. The existing populations are localized to certain reaches of watersheds where there is appropriate habitat. This population isolation leaves them vulnerable to localized extinctions from intentional or accidental toxic chemical spills, habitat modification, progressive degradation from runoff (non-point source pollutants), natural catastrophic changes to their habitat (e.g., flood scour, drought), other stochastic disturbances, and to decreased fitness from reduced genetic diversity (USFWS, 2016).

Stressor: Water quality degradation (USFWS, 2022)
Exposure:
Response:
Consequence:
Narrative: Water quality within the Locust Fork and Cahaba River are threatened by urban and industrial growth. Due to continued and increasing urban development around the Birmingham metropolitan area, water quality threats from sedimentation, urban runoff, effluents related to stormwater runoff, historical and present mining operations, and toxic spills continue to pose threats to this species. During periods of low water levels, phytoplankton growth increases as-aresult-of municipal and industrial wastewater discharges (Putt 2003). During periods of high stream flow, agricultural runoff and channel erosion impact water quality (Putt 2003). The species is vulnerable to yearly precipitation amounts as well as from extirpation from catastrophic events which have been noted throughout the watersheds over the last 100 years (Hudgins et al. 1984; Shepard et al. 2018). Additionally, climate change posses a threat to this species (USFWS, 2022)

Recovery

Reclassification Criteria:
1. The Cahaba shiner occurs in numbers that allow the capture of at least 5 per hour with the use of a 12 foot seine in suitable habitat throughout the 76 miles of historic range (USFWS, 1992).

2. Populations are documented to be viable over 10 years (USFWS, 1992).

3. The Cahaba River drainage is protected from water quality degradation (USFWS, 1992).

Criterion 1. Cahaba shiner populations in the Cahaba River and Locust Fork River systems exhibit stable or increasing trends over 10-year period, evidenced by natural recmitment, and multiple age classes (Factors A, D, E). Criterion 2. The Cahaba River and Locust Fork drainages are protected from water quality degradation and other foreseeable threats. Protected is defined as having enough control over the geographic area in question that adverse impacts to the water quality, water quantity, geomorphic design of the water course, and substrate are unlikely to occur (Factors A, D) (USFWS, 2019).

Recovery Priority Number: 8

Delisting Criteria:
In addition to meeting downlisting criteria 1-2, Cahaba shiner will be considered for delisting when: Criterion 3. Three additional populations in separate drainages, are discovered or established, and are shown to have a stable or increasing trend over a 10-year period, evidenced by natural recruitment, and multiple age classes (Factors A, D, E) (USFWS, 2019).

Recovery Actions:
- Determine the impact of effluents (USFWS, 1992).
- Determine life history of the Cahaba shiner (USFWS, 1992).
- Restore and protect historic habitat (USFWS, 1992).
- Monitor the population (USFWS, 1992).
- New Recovery Priority Number: 8 (USFWS, 2016).
- The U.S. Fish and Wildlife Service (Service) has contracted with the Alabama Department of Conservation and Natural Resources to begin population monitoring that will develop a baseline for evaluating population trends and recovery efforts (USFWS, 1992).
- The Geological Survey of Alabama has completed a 2-year study of water quality in the Cahaba River with sampling stations within the range of the Cahaba shiner. The data from that study has resulted in a cooperative study between the Service and Geological Survey of Alabama to evaluate water quality and species diversity at points upstream of the Cahaba shiner's range (USFWS, 1992).
- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Initiate long-term monitoring and population viability analysis of the species at sites within the Cahaba River and Locust Fork River basins. 2. Continue to survey suitable habitat within the Cahaba River and Locust Fork River basins for Cahaba shiners. 3. Explore the use of new technology in surveying, specifically environmental DNA survey methods. 4. Work to obtain protection for riverine and tributary buffering on privately owned lands specifically by forming relationships with landowners

and working with conservation groups, state, county and town governments. 5. Establish best management and conservation practices to improve water quality and water quantity issues by reducing stormwater runoff, sediment and eutrophication. 6. Formalize protection through cooperative agreement, conservation easement, fee title purchase or other means to guarantee safeguards to the water quality, especially turbidity, water quantity, geomorphology, hydrology and other aspects of the habitat and natural history of the species. 7. Enforce existing regulations and land management laws along with implementation of existing conservation and water quality and water quantity plans. 8. Devise a husbandry and augmentation plan for existing Cahaba shiner populations in both systems and begin propagation, husbandry and maintaining captive colonies of the species. 9. Revise recovery plan (USFWS, 2016).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES A detailed discussion of recovery actions and criteria are presented in the Recovery Plan (USFWS 1992) and Cahaba shiner Recovery Plan Amendment (USFWS 2019). Recovery Activities 1. Initiate long-term monitoring and population viability analysis of the species at sites within the Cahaba River and Locust Fork River basins. 2. Continue to survey suitable habitat within the Cahaba River and Locust Fork River basins for Cahaba shiners. 3. Define the minimum viable population size for this shiner to include population metrics, age classes, collection numbers, and mortality and natality. 4. Statistical confidence intervals need to be established to propose viable benchmarks of the species populations to indicate species health along with the inclusion of factors identified for persistence in populations to include stochastic and deterministic factors. 5. Explore the use of new technology in surveying, specifically environmental DNA (eDNA) survey methods. 6. Work to obtain protection for riverine and tributary buffering on privately owned lands specifically, by forming relationships with landowners and working with conservation groups, state, county, and municipal governments. 7. Establish best management and conservation practices to improve water quality and water quantity issues by reducing stormwater runoff, sediment, and eutrophication. 8. Formalize protection through cooperative agreements, conservation easement, fee title purchase or other means to guarantee safeguards to water quality, especially to address turbidity, water quantity, geomorphology, hydrology, and other aspects of the habitat. 9. Devise a husbandry and augmentation plan for existing Cahaba shiner populations in both systems and begin propagation, husbandry and maintaining captive colonies of the species. 10. Conduct research to compare water quality in the Locust Fork and Cahaba River to better understand differences and determine species abundance in the Cahaba River basin compared with the Locust Fork basin. 11. Revise and update recovery plan based on improved conditions in the Locust Fork (USFWS, 2022).

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SPECIES ACCOUNT: *Notropis girardi* (Arkansas River shiner)

Species Taxonomic and Listing Information

Commonly-used Acronym: ARS

Listing Status: Threatened; 11/23/1998; Southwest Region (R2) (USFWS, 2016)

Physical Description

The ARS is a small, robust minnow with a small, dorsally flattened head, rounded snout, and small subterminal mouth (Miller and Robison 1973, Robison and Buchanan 1988). Dorsal coloration tends to be light tan, with silvery sides gradually grading to white on the belly. Adults attain a maximum length of about 2 in (5.1 cm). Dorsal, anal, and pelvic fins all have eight rays, and there is usually a small, black chevron present at the base of the caudal fin.

Current Range

The ARS was first reported in 1926 from the Cimarron River northwest of Kenton, Cimarron County, Oklahoma (Hubbs and Ortenburger 1929). Historically, the ARS was widespread and abundant throughout the western portion of the Arkansas River basin in Kansas, New Mexico, Oklahoma, and Texas, but has subsequently disappeared from over 80 percent of its historical range. The current range is almost entirely restricted to about 508 miles of the Canadian River in Oklahoma, Texas, and New Mexico. An extremely small population may still persist in the Cimarron River in Oklahoma and Kansas, based on the collection of only 22 individuals since 1985. A remnant population also may persist in the Beaver North Canadian River of Oklahoma, based on collection of only four individuals since 1989 (Larson et al. 1991; Pigg 1991). However, samples collected by Wilde (2002) at 10 sites along the Beaver North Canadian River in 2000 and 200 1 found no ARS, suggesting that the ARS may be extirpated from that river. An accurate assessment of ARS populations in the Cimarron and Beaver North Canadian Rivers is difficult because the populations are likely so small that individuals may escape detection during routine surveys. The ARS is now believed to be extirpated from the entire Arkansas River.

Critical Habitat Designated

Yes; 10/13/2005.

Legal Description

On October 13, 2005, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Notropis girardi (Arkansas River Shiner) under the Endangered Species Act of 1973, as amended (Act) (70 FR 59808 - 59846). This critical habitat replaced critical habitat designated on April 4, 2001 (66 FR 18002 - 18034), which had been vacated by court order in September 2003. The 2005 critical habitat designation includes two critical habitat units (CHUs), in Kansas and Oklahoma (approximately 856 kilometers (532 miles) of linear distance of rivers, including 91.4 meters (300 feet) of adjacent riparian areas measured laterally from each bank are included within the boundaries of the critical habitat designation (70 FR 59808-59846).

Critical Habitat Designation

The critical habitat designation for Notropis girardi includes two CHUs in Clark, Comanche, Meade, and Seward Counties, Kansas; and Beaver, Blaine, Caddo, Canadian, Cleveland, Custer, Grady, Harper, Hughes, Kingfisher, Logan, Major, McClain, McIntosh, Pittsburg, Pontotoc, Pottawatomie, Seminole, Woods and Woodward Counties, Oklahoma (70 FR 59808-59846).

Unit 1b. Canadian River— approximately 396 km (246 mi), extending from the State Highway 33 bridge near Thomas, Oklahoma (IM T.15 N., R. 14 W., SW1/4 SE1/4 Sec. 15) downstream to Indian Nation Turnpike bridge northwest of McAlester, Oklahoma (IM T.8N., R.13E., SE1/4 SW1/4 SE1/4 Sec. 23)

Unit 3. Cimarron River— approximately 460 km (286 mi), extending from U.S. Highway 54 bridge in Seward County, Kansas (SPM, T. 33 S., R. 32 W., Sec. 25) downstream to U.S. Highway 77 bridge in Logan County, Oklahoma (IM, T. 17 N., R. 2 W., Sec. 29).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Notropis girardi critical habitat consists of six components in Kansas and Oklahoma (70 FR 59808-59846):

(i) a natural, unregulated hydrologic regime complete with episodes of flood and drought or, if flows are modified or regulated, a hydrologic regime characterized by the duration, magnitude, and frequency of flow events capable of forming and maintaining channel and instream habitat necessary for particular Arkansas River shiner life-stages in appropriate seasons.

(ii) a complex, braided channel with pool, riffle (shallow area in a streambed causing ripples), run, and backwater components that provide a suitable variety of depths and current velocities in appropriate seasons.

(iii) a suitable unimpounded stretch of flowing water of sufficient length to allow hatching and development of the larvae.

(iv) a river bed of predominantly sand, with some patches of gravel and cobble.

(v) water quality characterized by low concentrations of contaminants and natural, daily and seasonally variable temperature, turbidity, conductivity, dissolved oxygen, and pH.

(vi) suitable reaches of aquatic habitat, as defined by primary constituent elements (i) through (v) above, and adjacent riparian habitat sufficient to support an abundant terrestrial, semiaquatic, and aquatic invertebrate food base

(vii) few or no predatory or competitive non-native fish species present.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the areas that contain the features determined to be essential for conservation may require special management considerations or protections. As we undertake the process of designating critical habitat for a species, we first evaluate lands defined by those physical and biological features essential to the conservation of the species for inclusion in the designation pursuant to section 3(5)(A) of the Act. Secondly, we then evaluate lands defined by those features to assess whether they may require special management considerations or protection. As discussed in this final rule, our proposed rule published on October 6, 2004 (69 FR 59859), and our previous final designation of critical habitat

(66 FR 18002, April 4, 2001), the Arkansas River shiner and its habitat are threatened by a multitude of humanrelated activities, including but not limited to, stream flow modification, habitat loss by inundation, channel drying by water diversion and groundwater mining, stream channelization, water quality degradation, and introduction of nonindigenous plant and animal species. While many of these threats operate concurrently and cumulatively with one another and with natural disturbances like drought, habitat loss and modification represents the most significant threat to the Arkansas River shiner. Consequently, we believe each area designated as critical habitat may require some level of management and/ or protection to address current and future threats to the Arkansas River shiner, maintain the primary constituent elements essential to its conservation, and ensure the overall recovery of the species. Further discussion of the threats specific to each unit that may require special management considerations or protection are further discussed in the ‘‘Unit Descriptions’’ section below. The range and numbers of the species has already been much reduced by these threats. Consequently, the remaining fragmented sections are more likely to be affected by influences from other factors such as drought, water withdrawals, and permitted and unpermitted wastewater discharges. Once habitats are isolated, other aggregations of Arkansas River shiner can no longer disperse into these reaches and help maintain or restore these populations. Isolation and segregation caused by habitat fragmentation can lead to a reduction in overall genetic diversity. Lande (1999) identified reduced genetic diversity as one of several factors influencing extinction in small populations. Therefore, to conserve and recover the fishes to the point where they no longer require the protection of the Act and may be delisted, it is important to maintain and protect all remaining genetically diverse populations of this species within its historic range. Within the historic range of the Arkansas River shiner, considerable reaches of formerly occupied habitat have been inundated by reservoirs. While these losses are permanent and cannot reasonably be restored, management of water releases, such as those from Ute Reservoir, can be carried out in a manner that minimizes any adverse impacts and facilitates maintenance of Arkansas River shiner habitat. Removal of the nonnative salt cedar also can free additional water that, with management, can further provide for the habitat needs of the Arkansas River shiner. Streamflow management combined with control of salt cedar can retard the channel narrowing that often occurs following a reduction in streamflow and can improve Arkansas River shiner habitat. In other portions of the historic range, a lack of reservoir releases and groundwater mining has drastically reduced streamflows necessary for maintenance of Arkansas River shiner habitat. In these areas, control of salt cedar and enhanced water conservation, for both municipal and agricultural uses, can help ensure adequate streamflow continues to occur. Considering the amount of free-flowing habitat required to sustain Arkansas River shiner reproduction (as discussed in the ‘‘Primary Constituent Element’’ section above), such management may be particularly beneficial in ensuring that suitable spawning, rearing, and nursery habitat persists. Introductions of nonnative species, whether intentional or accidental, often have deleterious impacts to native species. The accidental introduction of the nonnative Red River shiner has negatively influenced the distribution and abundance of the Arkansas River shiner in the Cimarron River. A further introduction into other portions of its historic range poses a considerable threat to the Arkansas River shiner. Management efforts to eradicate the Red River shiner and eliminate or reduce the potential for additional releases of this species would be beneficial to the survival of the Arkansas River shiner.

Life History

Feeding Narrative

Adult: The ARS is believed to be a generalized forager and feeds upon both items suspended in the water column and items lying on the substrate (Jimenez 1999, Bonner et al. 1997). In the Canadian River of central Oklahoma, Polivka and Matthews (1997) found that gut contents were dominated by sand/sediment and detritus (decaying organic material) with invertebrate prey being an incidental component of the diet. In the Canadian River of New Mexico and Texas the diet of ARS was dominated by detritus, invertebrates, grass seeds, sand and silt (Jimenez 1999). Invertebrates were the most important food item, followed by detrital material. Terrestrial and semiaquatic invertebrates were consumed at higher levels than were aquatic invertebrates (Jimenez 1999). With the exception of the winter season, when larval flies were consumed much more frequently than other aquatic invertebrates, no particular invertebrate taxa dominated the diet (Bonner et al. 1997).

Reproduction Narrative

Adult: ARS specimens are open-water, broadcast spawners that release their eggs and spenn over an unprepared substrate (platania and Altenbach 1998, Johnston 1999). Examination of ARS gonadal development between 1996 and 1998 in the Canadian River of New Mexico and Texas demonstrated that the species undergoes multiple, asynchronous spawns in a single season (Wilde et al. 2000). The ARS appears to be in peak reproductive condition throughout the months of May, June, and July (Wilde et al. 2000, Polivka and Matthews 1997); however, spawning may occur as early as April and as late as September. Arkansas River shiner specimens may, on occasion, spawn in standing waters (Wilde et al. 2000), but it is unlikely that such events are successful. Evidence from Wilde et al. (2000) indirectly supports the speculation by Cross et al. (1985) that the ARS initiates an upstream spawning migration. Whether this represents a true spawning migration or just a general tendency in these fish to orient into the current and move upstream, perhaps in search of more favorable environmental conditions, is unknown (Wilde et al. 2000). Regardless, strong evidence suggested the presence of a directed, upstream movement by the ARS over the course of a year. Successful reproduction by the ARS appears to be strongly correlated with streamflow. Moore (1944) believed the ARS spawned in July, usually coinciding with elevated flows following heavy rains associated with summertime thunderstonns. Bestgen et al. (1989) found that spawning in the nonnative population of ARS in the Pecos River of New Mexico generally occurred in conjunction with releases from Sumner Reservoir. However, recent studies by Polivka and Matthews (1997) and Wilde et al. (2000) neither conflnned nor rejected the hypothesis that elevated streamflow triggered spawning in the ARS. Both Moore (1944) and Platania and Altenbach (1998) described behavior of ARS eggs. The fertilized eggs are nonadhesive and semibuoyant. Platania and Altenbach (1998) found that spawned eggs settled to the bottom of the aquaria where they quickly absorbed water and expanded. Upon absorbing water, the eggs became more buoyant, rose with the water current, and remained in suspension. The eggs would sink when water current was not maintained in the aquaria. This led Platania and Altenbach (1998) to conclude that the ARS and other plains fishes likely spawn in the upper to mid-water column during elevated flows. Spawning under these conditions would allow the eggs to remain suspended during the 10- to 30- minute period the eggs were non-buoyant. Once the egg became buoyant, it would remain suspended in the water column as long as current was present. In the absence of sufficient streamfiows, the eggs would likely settle to the channel bottom, where silt and shifting substrates would smother the eggs, hindering oxygen uptake and causing mortality of the embryos. Spawning during elevated flows appears to be an adaptation that likely increases survival of the embryo and facilitates dispersal of the young. Assuming a conservative drift rate of3 km/hour, Platania and Altenbach (1998) estimated that the fertilized eggs could be transported 45-89 mi (72-144 kIn) before hatching.

Developing larvae could then be transported up to an additiona1134 mi (216 kIn) before they were capable of directed swimming movements. Bonner and Wilde (2000) speculate that 135 mi (218 kIn) may be the minimum length of unimpounded river that allows for the successful completion of ARS life history, based on their observations in the Canadian River in New Mexico and Texas. Rapid hatching and development of the young is likely another adaptation in plains fishes that enhances survival in the harsh environments of plains streams. Arkansas River shiner eggs hatch in 24 to 48 hours after spawning, depending upon water temperature (Moore 1944, Platania and Altenbach 1998). The larvae are capable of swimming within 3 - 4 days; they then seek out low-velocity habitats, such as backwater pools and quiet water at the mouths of tributaries where food is more abundant (Moore 1944). Age and Growth Maximum longevity is unknown, but Moore (1944) speculated that the species' life span is likely less than 3 years in the wild. The age structure of ARS collected from the Pecos River in New Mexico included three, and possibly four, age classes (Bestgen et al.1989). The majority of the fish captured were juveniles (Age-O) and first-time spawners (Age-n. Most of the fish in spawning condition were Age-I. Bestgen et al. (1989) thought mortality of post-spawning fish was extremely high based on the absence of Age-I and older fish from collections made after the spawning period (late July and August).

Habitat Narrative

Adult: The ARS historically inhabited the main channels of wide, shallow, sandy bottomed rivers and larger streams of the Arkansas River basin (Gilbert 1980). Adults are uncommon in pools or backwaters, and almost never occur in tributaries having deep water and bottoms of mud or stone (Cross 1967). Polivka and Matthews (1997) suggested that juvenile ARS associate most strongly with current, conductivity (related to total dissolved solids), and backwater and island habitat types. Cross (1967) believed that adults preferred to orient into the current on the lee sides of transverse sand ridges and feed upon organisms washed downstream. The ARS is adapted to the shallow and moderately-turbid water typical of the sandy-bottomed rivers and streams inhabited by this species in the Arkansas River drainage (Bonner and Wilde 2002). Although moderate levels of turbidity may enhance the detection of prey by the ARS, the consumption of food items has been shown to decrease in highly turbid conditions (Bonner and Wilde 2002). In addition, a reduction in aquatic macroinvertebrates may occur as a result of increased sediment loads in the River, and this would be expected to reduce the availability of food for the ARS (Henley et al. 2000). The effect on the availability of aquatic invertebrate prey may be of short duration, however, as these organisms may rapidly return to the affected area; in addition, terrestrial and semiaquatic invertebrates may constitute a significant portion of the ARS diet (Jimenez 1999), and would be less susceptible to sediment loading in the channel. Sediment loading in streams resulting from highway construction has been shown to influence turbidity as much as 6.2 miles (10 km) downstream from the site of construction activity (Hainly 1980). Matthews (1987) classified several species of fishes, including the ARS, based on their tolerance for adverse conditions and selectivity for physicochemical gradients. The ARS was described as having a high thermal and oxygen tolerance, indicating a high capacity to tolerate elevated temperatures and low dissolved oxygen concentrations (Matthews 1987). Observations from the Canadian River in New Mexico and Texas revealed that dissolved oxygen concentrations, conductivity, and pH rarely influenced habitat selection by the ARS (Wilde et al. 2000). ARS specimens were collected over a wide range of conditions-water temperatures from 32.7 to 98.20 F (0.4 to 36.80 C), dissolved oxygen from 3.4 to 16.3 parts per million, conductivity (total dissolved solids) from 0.7 to 14.4 millisiemens per centimeter, and pH from 5.6 to 9.0. In the Canadian River of central Oklahoma, Polivka and Matthews (1997) found that ARS exhibited only a weak relationship between the environmental variables they measured and the occurrence of the species within the stream channel. Water depth, current, dissolved oxygen, and sand ridge and midchannel habitats were the environmental variables most strongly associated with the distribution of ARS within the channel. Similarly, microhabitat selection by ARS in the Canadian River of New Mexico and Texas was influenced by water depth, current velocity, and, to a lesser extent, water temperature (Wilde et al. 2000). The ARS specimens generally occurred at mean water depths between 6.6-8.3 in (17 and 21 cm) and current velocities between 11.7 and 16.4 in (29.7 and 41.7 cm) per second. Wilde et al. (2000) found no obvious selection for, or avoidance of, any particular habitat type (i.e., main channel, side channel, backwaters, and pools) by ARS. The ARS specimens did tend to select side channels and backwaters slightly more than expected based on the availability of these habitats (Wilde et al. 2000). Likewise, they appeared to make no obvious selection for, or avoidance of, any particular substrate type. Substrates in the Canadian River in New Mexico and Texas were predominantly sand; however, the ARS was observed to occur over silt slightly more than expected based on the availability of this substrate (Wilde et al. 2000).

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Population Information and Trends

Population Trends:

Possibly extirpated

Resiliency:

Current Population Resiliency Within this analysis, resiliency is based on a combination of demographic species factors and habitat/flow factors, which we classified as high, moderate, low, or null for each resiliency unit (i.e., river systems). The null rating is used for rivers when Arkansas River shiner have been extirpated. Based on the demographic and habitat factors used to describe resiliency in the SSA report, we described an overall level of resiliency by river (Table 1). Our analysis found that in the two resiliency units currently occupied by the Arkansas River shiner, both units have an overall moderate level of resiliency. For a full explanation of our resiliency analysis, see chapter 4 of the SSA report. (USFWS, 2020)

Representation:

Current Species Representation Best-available information suggests that the Arkansas River shiner has representation in the form of genetic diversity in three areas: (1) The South Canadian River upstream of Lake Meredith, Texas (from samples in the headwaters of the South Canadian River in New Mexico and its tributary Reveulto Creek), (2) The South Canadian River downstream of Lake Meredith, Texas (in Oklahoma) and (3) the introduced population in the Pecos River, New Mexico. Genetic diversity is relatively high in each of these three populations, but there does not appear to be significant differences in genetic makeup between the three populations (Osborn 2010 – see additional discussion in section 2.2 above). Representation in the form of ecological diversity across the extant populations of Arkansas River shiners is unknown. Given the species' historical wide-ranging geographic distribution and varying habitat conditions among Arkansas River basin rivers, it is likely that ecological diversity was lost when the Arkansas River shiner was extirpated from these rivers. (USFWS, 2020)

Redundancy:

Current Species Redundancy Historically, Arkansas River shiner inhabited six major river systems, as described in the Current Population Resiliency section above. Without the presence of dams, it is likely that each of these local populations dispersed throughout the Arkansas River basin and exhibited some level of genetic exchange between these large rivers. However, the species is now extirpated from all but two (Upper and Lower South Canadian River) river systems and the species' overall distribution has declined from 3,896 to 673 river miles, an 83 percent decline. More recent (although relatively limited) surveys within the last 5-10 years have failed to capture Arkansas River shiner within Texas downstream of Lake Meredith and far western Oklahoma, suggesting the Lower South Canadian River population's distribution may be contracting. Additional information provided to the Service as a part of our solicitation for additional information supports our current analysis of the species' distribution. Given the current level of redundancy across the range, the species as a whole has a higher risk of future extinction as compared to historical conditions. (USFWS, 2020)

Number of Populations:

2 (USFWS, 2020)

Population Narrative:

An extremely small population may still persist in the Cimarron River in Oklahoma and Kansas, based on the collection of only 22 individuals since 1985. A remnant population also may persist in the Beaver North Canadian River of Oklahoma, based on collection of only four individuals since 1989 (Larson et al. 1991; Pigg 1991). However, samples collected by Wilde (2002) at 10 sites along the Beaver North Canadian River in 2000 and 200 1 found no ARS, suggesting that the ARS may be extirpated from that river. An accurate assessment of ARS populations in the Cimarron and Beaver North Canadian Rivers is difficult because the populations are likely so small that individuals may escape detection during routine surveys. The ARS is now believed to be extirpated from the entire Arkansas River.

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative: No studies have been conducted on the impact of disease or predation upon the ARS; therefore, the significance of these threats upon existing populations is unknown. There is no direct evidence to suggest that disease threatens the continued existence of the species. Disease is not likely to be a significant threat except in isolated instances or under certain habitat conditions, such as crowding during periods of reduced flows, or episodes of poor water quality (e.g., low dissolved oxygen or elevated nutrient levels). During these events stress reduces resistance to pathogens, and disease outbreaks may occur. Parasites and bacterial and viral agents are generally the most common causes of mortality. Lesions caused by injuries, bacterial infections, and parasites often become the sites of secondary fungal infections; Some predation of ARS by largemouth bass Micropterus salmoides, green sunfish Lepomis cyanel/us, channel catfish leta/urus punctatus, and other fish species undoubtedly occurs, but the extent is

unknown.

Stressor: Predation
Exposure:
Response:
Consequence:
Narrative: Predation by aquatic birds (e.g., terns, herons, and egrets) and aquatic reptiles (e.g., snakes and turtles) also may occur (U.S. Fish and Wildlife Service 2005). Plains fishes have evolved under adverse conditions of widely fluctuating, often intennittent flows, high summer temperatures, high rates of evaporation, and high concentrations of dissolved solids. These conditions are not favored by most large predaceous fish and tend to preclude existence of significant populations of these species. However, alteration of historic flow regimes and construction of reservoirs have created favorable conditions for some predatory species such as white bass Morone chrysops and striped bass M saxatilis. State and Federal fish and wildlife management agencies, through cooperative efforts to develop sport fisheries in these reservoirs have facilitated expansion of the distributions of some predatory species. The impact of predation to the species is likely to be localized and insignificant, particularly where habitat conditions upstream of mainstem reservoirs are not favorable to the long-term establishment of abundant predatory fish populations.

Stressor: Reservoir construction
Exposure:
Response:
Consequence:
Narrative: Reservoir construction is the most widespread cause of habitat loss for the ARS. Numerous multipurpose impoundments, including three mainstem reservoirs on the Arkansas River (John Martin, Kaw, and Keystone) and four mainstem reservoirs on the Canadian River (Conchas, Ute, Meredith, and Eufaula) have been constructed within the Arkansas River basin. Other large mainstem impoundments also have been constructed within the historical range of the ARS, Optima and Canton reservoirs on the North Canadian River, and Great Salt Plains Reservoir on the Salt Fork of the Arkansas River. All of these impoundments have inundated, dewatered, fragmented, or otherwise directly altered considerable sections of riverine habitat once inhabited by ARS. ARS populations persist only below Ute Reservoir in New Mexico and Lake Meredith in Texas (Bonner et al. 1997; Larson et al. 1991; Pigg 1991).

Stressor: Inundation following impoundment
Exposure:
Response:
Consequence:
Narrative: Inundation following impoundment eliminated ARS spawning habitat, isolated populations, and favored increased abundance of predators both upstream and downstream of these reservoirs. Water releases from impoundments may be infrequent or non-existent in the western portions of the Arkansas River basin causing streams to be dewatered for considerable distances downstream of the reservoir. Impoundments also function as barriers, fragmenting populations and habitat into smaller, more isolated units. These fragmented, smaller sections may affect the ARS's ability to reproduce. Wilde et al. (2000) suggested that an unimpounded stretch of the river approximately 137 miles (220.5 km) long may be necessary for the ARS to complete its life cycle. Additionally, these fragmented sections are more likely to be affected by

influences from external factors (e.g., localized drought, water withdrawals, permitted and unpermitted wastewater discharges). Once isolated, other aggregations of ARS can no longer disperse into these reaches and help maintain or restore populations of ARS there.

Stressor: Altered flows
Exposure:
Response:
Consequence:
Narrative: Altered flows downstream of Lake Meredith, and to a lesser extent below Ute Reservoir, have considerably changed the morphology of the Canadian River and have reduced the extent of suitable habitat for ARS. Stinnett et al. (1988) examined a 230 mile (370.2 km) stretch of the Canadian River and associated 179,495 acres (72,639 ha) of floodplain between the western Oklahoma border and the western Pottawatomie County line near Norman, Oklahoma. Between 1955 and 1984, the amount of riverine wetlands (shoreline and open water) decreased by about 50 percent. Sandbar acreage alone had been reduced by 54 percent. Wetland and associated floodplain changes were principally the result of hydrological modifications due to the influence of Lake Meredith (Stinnett et al. 1988). The resulting reduction in significant scouring flows within the study reach permitted the encroachment of woody vegetation into the channel, reducing channel width by almost 50 percent since 1955. Although the core population of ARS persists in the Canadian River, the reduction in available habitat downstream of Ute Reservoir and Lake Meredith likely has suppressed ARS populations in affected reaches. Habitat alterations associated with reduced flows downstream of Lake Meredith are considered to be a significant, ongoing threat to the long term survival of the ARS within the Canadian River. In addition to altered stream flows from reservoir management, the decline of ARS throughout its historical range also may primarily be attributed to destruction and modification of habitat by one or more of the following: stream channelization, stream flow alteration and depletion, and, to a lesser extent, water quality degradation.

Stressor: Channelization
Exposure:
Response:
Consequence:
Narrative: Channelization causes a variety of changes in natural stream channels, including channel shape, form, and width; water depth, substrate type; stream gradient; stream flow velocity; and the hydroperiod (Simpson et al. 1982). Channelization of the Arkansas River has permanently altered and eliminated suitable habitat for the ARS and is largely responsible for the extirpation of the ARS within the State of Arkansas. Channelization of the Arkansas River also has contributed to the decline of the species in Oklahoma, downstream of Muskogee, Oklahoma, ARS were last observed in 1985 (Pigg 1991).

Stressor: Surface water withdrawals
Exposure:
Response:
Consequence:
Narrative: Surface water withdrawals constitute a small percentage of the total water used within the western sections of the historical range of the ARS, primarily because of the limited number of impoundments and elevated levels of chlorides.

Stressor: Poor water quality
Exposure:
Response:
Consequence:
Narrative: Poor water quality from nutrients, sediments, chemicals and other types of non-point source pollutants, is believed to have contributed to localized ARS population declines (U. S. Fish and Wildlife Service 2007). Some agricultural practices have contributed to water quality degradation in the Arkansas River basin, resulting in impacts to ARS aggregations. Agriculture can be a key contributor of nutrients, sediments, chemicals, and other types of non-point source pollutants, primarily due to runoff from range, pastureland and tilled fields. The U.S. Environmental Protection Agency (EPA) found that agricultural practices were the primary source of water quality impairment in both rivers and lakes and were responsible for the impairment of 72 percent of the stream miles assessed nationwide in 1992 and 25 percent in 1996 (U.S. Environmental Protection .A.gency 1994, 1998). The decline reported in 1996 was largely due to an expansion of the national estimate of total river miles to include non-perennial streams, canals, and ditches, which essentially doubled the total river miles surveyed since 1992 (U.S. Environmental Protection Agency 1998). Siltation and nutrient pollution were the leading causes of water quality impairment in both studies. Increased nutrients promote eutrophication of aquatic ecosystems, including the growth of bacteria, algae, and nuisance aquatic plants, and lower oxygen levels.

Stressor: Overgrazing
Exposure:
Response:
Consequence:
Narrative: Overgrazing of riparian areas also can affect ARS habitat. Overgrazing in riparian zones is likely to be locally detrimental and is one of the most common causes of riparian and water quality degradation (Kauffman and Krueger 1984). High livestock densities may result in excessive physical disturbances, such as trampling, and changes in water quality. Trampling of pool margins and thinning of vegetation from overgrazing induce changes in the plant community structure, species composition, relative species abundance, and plant density, which often are linked to more widespread changes in watershed hydrology. In addition to increased sedimentation, the most apparent effects on fish habitat are reductions of shade, cover, and terrestrial food supply, and the resultant increases in stream temperature, changes in water quality and stream morphology. The overall trend in the status of the ARS has been characterized by dramatic declines in numbers and range despite the fact that this species evolved in rapidly fluctuating, harsh environments. None of the threats affecting the ARS have been eliminated since the species was listed. The ARS also remains vulnerable to those natural or manmade factors, such as the introduction of the Red River shiner or a prolonged period of low or no flow, which increase stressors to the population, further reducing population size. If recovery actions fail to reverse ARS declines, the species' vulnerability to catastrophic events such as accidental spills will increase.

Recovery

Delisting Criteria:
1. Three wild, self-sustaining populations of Arkansas River shiner exist in the historical range (USFWS, 2024).

2. River connectivity throughout all three populations is sufficient to support the species' life history (USFWS, 2024).

3. Flow patterns throughout all three populations reflect a natural flow regime (USFWS, 2024).

Recovery Actions:

- During low flow conditions, work roads shall be constructed in a manner such that stream flow is maintained. During these low flow conditions, it is possible that the placement of a work road could temporarily impede flow and create isolated pools downstream of the structure. To ensure flow is not impeded and isolated pools do not develop, the channel would be artificially routed around the work road and back into the existing channel just downstream of the road.
- Vehicles or other motorized equipment shall be confined to areas outside of the wetted channel of the Canadian River, with the exception of activities related to work road construction and use. Once the use of the first work road is complete, motorized equipment shall not be driven through the wetted channel. The existing bridge shall be used to transport equipment from one side of the Canadian River to the other.
- After use of each work road is no longer needed, fill material shall be removed and the natural contours of the river channel and bank restored to the maximum extent practicable.
- Appropriate best management practices, as established by the ODEQ, to minimize impacts from storm water discharges, shall be incorporated into the project specifications and included as part of the project plans.
- Refueling of construction equipment also shall be conducted at least 300 feet outside of the OHWM.
- Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans or develop information. Implementation of these measures would further help to minimize effects to the ARS. The Service recommends that the FHWA and ODOT contribute to the continued survey efforts of the ARS. These survey efforts are used on a regular basis by FHW A and ODOT for endangered species consultations on a wide variety of construction projects across the state of Oklahoma. Contributions could be made in the form of funding the Oklahoma Department of Wildlife Conservation or the Service for the surveying work, providing biological staff as field support during surveying, or funding the identification of field samples collected during surveying. In order for the Service to be kept informed of actions that either minimize or avoid adverse effects or benefit listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.
- 1. Develop and implement water management strategies in both the Upper and Lower South Canadian Priority 1 management units (USFWS, 2024).
- 2. Evaluate the three Priority 2 management units (Arkansas River, Cimarron, and North Canadian rivers) and develop priorities for Arkansas River shiner reintroductions (USFWS, 2024).
- 3. Develop and implement water management strategies for the Priority 2 management units identified through implementation of Action 2 above (USFWS, 2024).

- 4. Develop and implement water management strategies for the Priority 2 management units identified through implementation of Action 2 above (USFWS, 2024).
- 5. Develop and implement water management strategies for the Priority 2 management units identified through implementation of Action 2 above (USFWS, 2024).
- 6. Develop and implement a plan for fish passage and flow barrier assessment and potential removal (USFWS, 2024)
- 7. Preclude the need for new reservoir development within the Upper and Lower South Canadian River and the Priority 1 management unit (USFWS, 2024)
- 8. Long-term management commitments or conservation agreements are implemented across the species range (USFWS, 2024)
- 9. Develop and implement water quality targets (USFWS, 2024).
- 10. Develop and implement best management practices for water quality (USFWS, 2024)
- 11. Research and develop hydrologic targets to determine flow patterns necessary to support Arkansas River shiner populations (USFWS, 2024)
- 12. Continue to implement a range-wide monitoring program. (USFWS, 2024)
- 13. Develop a comprehensive captive propagation and contingency plan (CPCP) consistent with the USFWS Policy regarding Controlled Propagation of Species Listed Under the Endangered Species Act (USFWS, 2024).
- 14. Establish and maintain a captive breeding program (USFWS, 2024)
- 15. Develop and Implement a Reintroduction Plan (USFWS, 2024)
- 16. Develop and Implement a Biobanking Plan (USFWS, 2024)
- 17. Continue to develop knowledge of the species' life history, ecology, habitat requirements and behavior and apply that knowledge to restore and protect appropriate habitats (USFWS, 2024)
- 18. Continue genetic studies on Arkansas River shiner populations (USFWS, 2024)
- 19. Improve understanding of the nature, extent, and role of water quality degradation in the decline of the species, as well as the water quality standards necessary for its protection and recovery (USFWS, 2024)
- 20. Improve understanding of climate change effects to river flows, water quality, and species viability (USFWS, 2024)
- 21. Improve understanding of the nature and extent of interaction between other fish species (native and non-native) and Arkansas River shiner, and the possible role of these species in the Arkansas River shiners' decline (USFWS, 2024)
- 22. Develop and implement a flexible, range-wide management program (USFWS, 2024)
- 23. Identify key partners for each management unit (USFWS, 2024)
- 24. Develop and implement a communications plan to enhance collaboration with partners (USFWS, 2024)
- 25. Integrate existing conservation plans (USFWS, 2024)
- 26. Develop and implement an outreach and communication plan for the Arkansas River shiner (USFWS, 2024)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Develop and implement a recovery plan for the Arkansas River shiner. Broad actions within the plan may include the following: 1. Restore and conserve habitats to support Arkansas River shiner life history requirements into the future - As described in the SSA report, flows and corresponding physical habitat such as channel complexity and channel width are declining. To ensure survival of the species, it will be necessary to restore and protect habitats with an ecosystem perspective, as well as develop and implement water management strategies that support suitable habitat characteristics into the future. Continue to work with State agencies, Canadian River Municipal Water Authority, landowners, and other parties to ensure adequate flow conditions for native fishes. 2. Maintain viable populations of Arkansas River shiner - Viability of the Arkansas River shiner into the future will benefit from at least three resilient populations across the species' range that represents the species breadth of genetic diversity and habitat types. Existing populations will be monitored to assess resiliency and captive propagation will be necessary to increase representation and redundancy of the species. 3. Further scientific understanding and develop a comprehensive and structured adaptive management program for Arkansas River shiner recovery - Southern Great Plains rivers and their associated aquatic and riparian habitats are complex and dynamic. There is uncertainty regarding the potential effects of various recovery actions on the Arkansas River shiner, water users, and the existing infrastructure. As our understanding of these systems increases, it may be necessary to adjust and refine the recovery strategy. This is the essence of adaptive management, which may be defined as management in the face of uncertainty, with a focus on reduction of uncertainty over time. 4. Design and implement a public awareness and information program – Continue to work with State agencies, Tribes, land owners, and other partners to develop public awareness of conservation opportunities and the issues and conditions that led to the Arkansas River shiners decline. Such a program should seek to inform the public on the issues and the rationale for management actions, encourage river and riparian conservation, and solicit their support for the Arkansas River shiner recovery program. An information and education program that actively involves all stakeholders and interested parties, and makes use of several means to reach and inform people should be developed. (USFWS, 2020)

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SPECIES ACCOUNT: *Notropis mekistocholas* (Cape Fear shiner)

Species Taxonomic and Listing Information

Listing Status: Endangered; 9/25/1987; Southeast Region (R4) (USFWS, 2015)

Physical Description

A small (rarely exceeding 2 inches in length), moderately stocky minnow. The body is flushed with a pale silvery yellow, and a black band runs along its side. The fins are yellowish and somewhat pointed. The upper lip is black, and the lower lip bears a thin black bar along its margin (USFWS, 1988).

Taxonomy

Unusual in the genus in possessing black parietal peritoneum and nearly unique in Notropis in having an elongate, convoluted intestine" (Lee et al. 1980). See Snelson (1971) for original description. (NatureServe, 2015)

Historical Range

Two historic populations have apparently been extirpated: Robeson Creek, Chatham county and Parkers Creek, Harnett county (Pottern and Huish 1985, 1986) (USFWS, 1988).

Current Range

This species is endemic to the Cape Fear River basin in the east-central Piedmont region of North Carolina, occurring within a 30-mile wide area along the Cape Fear River and tributaries near the Fall Line (Page and Burr 2011). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/25/1987.

Legal Description

On September 25, 1987, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Notropis mekistocholas (Cape Fear shiner) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes three critical habitat units (CHUs) in North Carolina (52 FR 36024-36039).

Critical Habitat Designation

The critical habitat designation for Notropis mekistocholas includes three CHUs in Chatham, Lee, Randolph and Moore Counties, North Carolina (52 FR 36024-36039).

(1) North Carolina, Chatham County. Approximately 4.1 river miles of the Rocky River from North Carolina State highway 902 Bridge downstream to Chatham County Road 1010 Bridge:

(2) North Carolina. Chatham and Lee Counties. Approximately 0.5 river mile of Bear Creek, from Chatham County Road 2156 Bridge downstream to the Rocky River, then downstream in the Rocky River [approximately 4.2 river miles) to the Deep River, then downstream in the Deep

River (approximately 2.6 river miles) to a point 0.3 river mile below the Moncure, North Carolina, U.S. Geological Survey Gaging Station: and

(3) North Carolina. Randolph and Moore Counties. Approximately 1.5 river miles of Fork Creek, from a point 0.1 river mile upstream of Randolph County Road 2873 Bridge downstream to the Deep River then downstream approximately 4.1 river miles of the Deep River in Randolph and Moore Counties, North Carolina, to a point 2.5 river miles below Moore County Road 1436 Bridge.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs for Notropis mekistocholas in North Carolina are not specified but are assumed to be the following (52 FR 35034-35041):

Stream sections that contain gravel, cobble and boulder substrates with pools, riffles, and shallow runs for adult fish and slackwater areas with large rock outcrops, side channels, and pools for juveniles. These areas also provide water of good quality with relatively low silt loads.

Life History

Feeding Narrative

Adult: Diet probably includes detritus, periphyton, and perhaps macroalgae. Highly specialized detritus- and plant-eating species (Page and Burr 1991). Adults and immatures are herbivores (NatureServe, 2015).

Reproduction Narrative

Adult: Apparently spawns in late spring and early summer (NatureServe, 2015).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Broad (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Moderate (inferred from NatureServe, 2015; see threats)

Habitat Narrative

Adult: Small rivers to medium-sized creeks near the Fall Line; areas of moderate gradient and riffles alternating with long deep pools, and substrate a mixture of sand-gravel, rubble, and boulders. Occurs in slow pools, riffles, slow runs. Juveniles occupy slackwater, areas near rock outcrops, and flooded areas (Lee et al. 1980, Page and Burr 1991). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Not available (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Not available (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Data on dispersal and other movements generally are not available (NatureServe, 2015).

Population Information and Trends

Population Trends:

Unknown - probably declining (NatureServe, 2015)

Species Trends:

< 30% decline (NatureServe, 2015)

Number of Populations:

1 population (3 subpopulations) (USFWS, 2022)

Population Size:

2500 - 10,000 individuals (NatureServe, 2015)

Minimum Viable Population Size:

1,500 - 3,000 individuals (NatureServe, 2015)

Population Narrative:

Formerly the species was more widespread in the Cape Fear system. Snelson (1971) suggested that Cape Fear Shiners may have always existed in low numbers, but unpublished studies from the 1980s (G. B. Pottern and M. T. Huish, U.S. Fish and Wildlife Service, Endangered Species Office, Asheville, NC) reported declines in abundance and range for the species that were not evident for other sympatric taxa. A recent, significant decline in effective population size in two populations (one in the Deep River downstream of the High Falls dam and one at the confluence of the Deep and Rocky Rivers) was inferred from genetic data (Saillant et al. 2004). Effective population sizes in the three largest populations are estimated to be between 1500 and 3000 individuals (USFWS, North Carolina Ecological Services; http://www.fws.gov/nc-es/fish/cfshiner.html, website last updated Sept 2006). Recorded from nine streams. At present, only five populations are thought to exist; two of the five remaining populations are very small and unstable and therefore at risk of extirpation (USFWS, North Carolina Ecological Services; http://www.fws.gov/nc-es/fish/cfshiner.html, website last updated Sept 2006). See also Saillant et al. (2005). The range extent is 400 - 2,000 square miles, with an estimated population size of 2,500 - 10,000 individuals. The population trend over the past 10 years or three generations is uncertain, but habitat quality and possibly abundance probably are slowly declining. The short-term trend is a decline of <30% to relatively stable (NatureServe, 2015). The Cape Fear shiner is a minnow native to five counties in the upper Cape Fear River Basin in central North Carolina. It is a narrow endemic, with a single population comprised of three subpopulations based on river subbasins – the Haw, Rocky-Deep, and Cape Fear. The species is most often found in rocky pools and runs adjacent to riffles in wide, shallow segments of rivers with gravel, cobble and/or boulder substrates with forested banks and abundant water willow (Justicia americana), riverweed (Podostemum ceratophyllum), stream mosses, and filamentous green algae. It was listed as an endangered species due to its small population size and threats to its habitat from dams and pollution. Figure 1 shows the most recent confirmed distribution of Cape Fear shiners following a 2020 range-wide survey by the North Carolina Wildlife Resources Commission. There were 56 sites surveyed including all of those visited during a 2007 range-wide survey, plus new tributaries and localities with suitable habitat. There were 416 Cape Fear shiners observed within the Rocky and Deep River systems. No individuals were observed in the Haw or Cape Fear River systems. The survey data and analyses were used as a foundation for the recent SSA (Service 2022). The 2022 SSA identified one Cape Fear shiner population, with three subpopulations in the Haw, Rocky-Deep, and upper Cape Fear River basins. Each subpopulation was further divided into eight management units (MUs), with two MUs in the Haw, four MUs in the Rocky-Deep, and two MUs in the Cape Fear. The current condition of each MU was assessed by examining population and habitat factors (USFWS, 2022).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 1988)
Exposure:
Response:
Consequence:
Narrative: Potential threats to Notropis mekistocholas and its habitat could come from such activities as land use changes, chemical spills, road construction, stream channel modification, changes in stream flow from hydroelectric power, impoundments, wastewater discharges, increases in agricultural runoff, deterioration of water quality through increases in siltation (USFWS, 1988).

Stressor: Potential toxic chemical spill (USFWS, 1987)
Exposure:
Response:
Consequence:
Narrative: The major portion of the Cape Fear shiner population is located at the junction of the Deep and Rocky Rivers in Chatham and Lee Counties, North Carolina. A major toxic chemical spill at the U.S. Highway 16-165 Bridge upstream of this site on the Rocky River could jeopardize this population, and as the other populations are extremely small and tenuous, the species' survival could be threatened (USFWS, 1987).

Stressor: Climate Change (USFWS, 2017)
Exposure:
Response:
Consequence:

Narrative: Likely impacts of climate change on aquatic species include increases is water temperature and changes and shifts in seasonal patterns of precipitation and runoff. Climate change is an additional stressor to sensitive freshwater systems, which are already adversely by a variety of other human impacts, such as altered flow regimes and deterioration of water quality. Aquatic ecosystems have a limited ability to adapt to climate change. Reducing the likelihood of significant impacts will largely depend on human activities that reduce other sources of ecosystem stress to ultimately enhance adaptive capacity; these include maintaining riparian forests, reducing nutrient loading, restoring damaged ecosystems, minimizing groundwater (and stream) withdrawal, and strategically placing any new reservoirs to minimize adverse effects. Specific ecological responses to climate change cannot be easily predicted because new combinations of native and non-native species will interact in novel situations (USFWS, 2017).

Recovery

Reclassification Criteria:
1. Through protection of existing populations and successful establishment of reintroduced populations or discovery of additional populations, a total of four distinct viable populations exist in the Cape Fear River basin (USFWS, 1988).

2. Studies of the fish's biological and ecological requirements have been completed and the implementation of management strategies developed from these studies have been or are likely to be successful (USFWS, 1988).

Recovery Priority Number: 8

Delisting Criteria:
4. Noticeable improvements in water and substrate quality have occurred to the species' habitat and the species has responded through natural means or with human assistance to successfully recolonize other streams and stream reaches within the Cape Fear River basin (USFWS, 1988).

1. Through protection of existing populations and successful establishment of reintroduced populations or discovery of additional populations, a total of six distinct viable populations exist in the Cape Fear River basin (USFWS, 1988).

2. Studies of the fish's biological and ecological requirements have been completed and the implementation of management strategies developed from these studies have been or are likely to be successful (USFWS, 1988).

3. No foreseeable threats exist that would likely threaten the survival of any of these six populations (USFWS, 1988).

Recovery Actions:
- Preserve present populations and presently used habitat (USFWS, 1988).
- Search for additional populations and/or habitat suitable for reintroduction efforts (USFWS, 1988).
- Determine the feasibility of reestablishing the Cape Fear shiner back into historic habitat and reintroduce where feasible (USFWS, 1988).

- Develop and implement a program to biennially monitor population levels and habitat conditions of presently established populations as well as newly discovered, introduced, or expanding populations (USFWS, 1988).
- Annually assess overall success of the recovery program and recommend action (changes in recovery objectives, delist, continue to protect, implement new measures, other studies, etc.) (USFWS, 1988).
- Recommendations for future actions: Additional research is needed to investigate the Cape Fear Shiner's biological and ecological requirements, conduct formal threats analyses, and develop techniques for reestablishing the shiner throughout its historical range. Specifically, these studies include the following: 1. Estimate the current population size of each Cape Fear Shiner location or site to generate a baseline against which population increases or decreases can be determined. 2. Develop population viability models for each location or site. 3. Investigate larval and juvenile dispersal ability. 4. Determine fecundity and demography. 5. Examine dispersal and habitat-use patterns to assess the extent of interaction between Cape Fear Shiner locations. 6. Assess biotic interactions between Cape Fear Shiners and introduced predators (Roanoke Bass and Flathead Catfish). 7. Assess the potential for disease transmission and/or predation during a Cape Fear Shine reintroduction or translocation event (whether captive or wild shiners are used for the population augmentation event (USFWS, 2017).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES A detailed discussion of recovery actions and criteria are presented in the recovery plan (Service 1988). The Cape Fear shiner's current ability to sustain populations in the wild, while improved since the time of listing, may not currently be sufficient for the species to overcome stochastic events into the future. Improved viability in the future will be reliant on human intervention – by reconnection of habitats via dam removals or passage, through species restoration efforts via captive propagation and augmentation, as well as maintaining adequate water quality and constant vigilance against the spread of invasive species. Dam construction along the upper Cape Fear, Deep, and Haw rivers as well as their tributaries has probably had the most serious impact on the Cape Fear shiner. The recent SSA (Service 2022) has a section on the relative benefit of various dam removal scenarios which can help prioritize river restoration for the species. Gaining an understanding of why the species is in such low numbers on the Haw and Cape Fear subpopulations is a priority given that the habitat conditions appear adequate (Service 2022) (USFWS, 2022).

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SPECIES ACCOUNT: *Notropis oxyrhynchus* (Sharpnose Shiner)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/04/2014; Southwest Region (Region 2) (USFWS, 2016)

Physical Description

A small fish (shiner). Adult sharpnose shiners are approximately 30 to 50mm in standard length, have a strongly curved ventral contour, oblique mouth, and pointed snout (Hubbs and Bonham, 1951). They are silver in color, with a faint lateral stripe extending from the gills to the tail. The anal fin is slightly falcate and usually has no more than nine rays; the dorsal fin has eight rays and begins behind the insertion of the pelvic fin (Hubbs and Bonham, 1951). (NatureServe, 2015)

Taxonomy

Taxon of unquestioned validity (Starnes 1995). (NatureServe, 2015)

Historical Range

The sharpnose shiner historically occurred throughout the Brazos River system, including the Double Mountain and Salt Forks of the Upper Brazos River drainage. (NatureServe, 2015)

Current Range

Sharpnose shiners are small minnows restricted to the contiguous river segments of the upper Brazos River basin in north-central Texas at the time of their listing. (USFWS, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/4/2014.

Legal Description

On August 4, 2014, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Notropis oxyrhynchus (Sharpnose shiner) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes six critical habitat units (CHUs) in Texas (79 FR 45242-45271).

Critical Habitat Designation

The critical habitat designation for Notropis oxyrhynchus includes six CHUs in Baylor, Crosby, Fisher, Garza, Haskell, Kent, King, Knox, Stonewall, Throckmorton, and Young Counties, Texas (79 FR 45242-45271).

Subunit 1: Brazos River Main Stem; Baylor, King, Knox, Stonewall, Throckmorton, and Young Counties, Texas. (i) Brazos River Main Stem from approximately 15 river km (9.3 miles) upstream of the eastern border of Young County where it intersects the upper portion of Possum Kingdom Lake (32.974302, ¥98.509880) upstream to the confluence of the Double Mountain Fork of the Brazos River and the Salt Fork of the Brazos River where they form the Brazos River main stem (33.268404, ¥100.010209)

Subunit 2: Salt Fork of the Brazos River; Garza, Kent, and Stonewall Counties, Texas. (i) Salt Fork of the Brazos River from its confluence with the Double Mountain Fork of the Brazos River (33.268404, ¥100.010209) upstream to the McDonald Road crossing (33.356258, ¥101.345890).

Subunit 3: White River; Crosby, Garza, and Kent Counties, Texas. (i) White River from its confluence with the Salt Fork of the Brazos River (33.241172, ¥100.936181) upstream to the White River Lake impoundment (33.457240, ¥101.084546).

Subunit 4: Double Mountain Fork of the Brazos River; Fisher, Haskell, Kent, and Stonewall Counties, Texas. (i) Double Mountain Fork of the Brazos River from its confluence with the Salt Fork of the Brazos River (33.268404, ¥100.010209) upstream to the confluence of the South Fork Double Mountain Fork of the Brazos River and the North Fork Double Mountain Fork of the Brazos River where they form the Double Mountain Fork of the Brazos River (33.100269, ¥100.999803).

Subunit 5: North Fork Double Mountain Fork of the Brazos River; Crosby, Garza, and Kent Counties, Texas. (i) North Fork Double Mountain Fork of the Brazos River from its confluence with the South Fork Double Mountain Fork of the Brazos River (33.100269, ¥100.999803) upstream to the earthen impoundment near Janes-Prentice Lake (33.431515, ¥101.479610).

Subunit 6: South Fork Double Mountain Fork of the Brazos River; Garza and Kent Counties, Texas. (i) South Fork Double Mountain Fork of the Brazos River from its confluence with the North Fork Double Mountain Fork of the Brazos River (33.100269, ¥100.999803) upstream to the John T. Montford Dam of Lake Alan Henry (33.065008, ¥101.039780).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Notropis oxyrhynchus critical habitat consists of four components in Texas (79 FR 45242-45271):

(1) Unobstructed, sandy-bottomed river segments greater than 275 km (171 mi) in length.

(2) Flowing water of greater than approximately 2.61 m3s¥1 (92 cfs) averaged over the shiner spawning season (April through September).

(3) Water of sufficient quality to support survival and reproduction, characterized by: a. Temperatures generally less than 39.2 °C (102.6 °F); b. Dissolved oxygen concentrations generally greater than 2.66 mg/L (2.66 ppm); c. Salinities generally less than 25 mS/cm (15 ppt); and d. Sufficiently low petroleum and other pollutant concentrations such that mortality does not occur.

(4) Native riparian vegetation capable of maintaining river water quality, providing a terrestrial prey base, and maintaining a healthy riparian ecosystem.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features that are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of these species may require special management considerations or protection to reduce the following threats: Habitat loss and modification from fragmentation of river segments; alteration to natural flow regimes by impoundment, groundwater withdrawal, and drought; water quality degradation; and invasive saltcedar encroachment. River fragmentation decreases the unobstructed river length required for successful reproduction in these species. Impoundments, groundwater withdrawal, saltcedar encroachment, and drought have the potential to reduce river flow below the minimum requirement to keep the eggs and larvae of these species afloat and ultimately for sustainment of sharpnose and smalleye shiner populations. Water quality degradation resulting from pollution sources; lack of flows maintaining adequate temperatures, oxygen concentrations, and salinities; and the destruction of adjacent riparian vegetation's run-off filtering abilities may result in water quality parameters beyond which sharpnose and smalleye shiners are capable of surviving. As such, the features essential to the conservation of these species may require special management from these threats. For sharpnose shiners and smalleye shiners, special management considerations or protection may be needed to address threats. Management activities that could ameliorate threats include, but are not limited to: (1) Removing or modifying existing minor fish barriers to allow fish passage; (2) managing existing reservoirs to allow sufficient river flow to support shiner reproduction and population growth; (3) protecting groundwater, surface water, and spring flow quantity; (4) protecting water quality by implementing comprehensive programs to control and reduce point sources and non-point sources of pollution; and (5) protecting and managing native riparian vegetation. A more complete discussion of the threats to the sharpnose shiner and smalleye shiner and their habitats can be found in the March 2014 SSA Report (Service 2014, Chapter 3).

Life History

Feeding Narrative

Adult: The diet is dominated by aquatic invertebrates such as dipterans, ostracods, trichopterans, odonata, coleopterans, and hemipterans, plus various terrestrial arthropods (Marks et al. 2001). These fishes often consume a large amount of sand/silt, which indicates that foraging occurs among sediment, as well as in the water column (Marks et al. 2001). Shiners are generalist feeders and have a maximum lifespan of less than three years. (NatureServe, 2015)

Reproduction Narrative

Adult: Shiners are generalist feeders and have a maximum lifespan of less than three years. However, it is believed most individuals survive only through one reproductive season, which generally occurs from April through September. Both species broadcast spawn eggs and sperm into open water asynchronously (fish not spawning at the same time) during periods of low flow and synchronously (many fish spawning at the same time) during periods of elevated streamflow from April through September (Durham 2007, p. 24; Durham and Wilde 2008, entire; Durham and Wilde 2009a, p. 26). Based on studies of similar species, their eggs are semi-buoyant and remain suspended one or two days in flowing water as they develop into larvae (Platania and Altenbach 1998, p. 565; Moore 1944, p. 211). Similarly, larval fish remain suspended in the flowing water column an additional two to three days as they develop into free-swimming juvenile fish (Moore 1944, pp. 211–212; Perkin and Gido 2011, p. 372). In the absence of sufficient water velocities, suspended eggs and larvae sink into the substrate where the majority likely die (Platania and Altenbach 1998, p. 565; Dudley and Platania 2007, p. 2083).

The reproductive strategy of these species makes them particularly vulnerable to changes in the natural conditions of occupied habitat. Given their short lifespans, most sharpnose and smalleye shiners survive through only one reproductive season (Durham 2007, p. 27). (USFWS, 2015)

Geographic or Habitat Restraints or Barriers

Adult: Population dynamics modeling estimates a mean summer water discharge of approximately 2.61 m3s-1 (92 cfs) is necessary to sustain populations of sharpnose shiners (Durham 2007, p. 110), while a higher mean discharge of approximately 6.43 m3s-1 (227 cfs) is necessary for smalleye shiners (Durham and Wilde 2009b, p. 670). (USFWS, 2015)

Environmental Specificity

Adult: Moderate (USFWS, 2015)

Tolerance Ranges/Thresholds

Adult: High (USFWS, 2015)

Habitat Narrative

Adult: Habitat includes sand and gravel runs of medium to large rivers; less often in sand- and mud-bottomed pools (Page and Burr 2011). Preferred habitat includes fairly shallow water (38 to 82 cm (15 to 32 in) in depth) in broad, open sandy channels with a moderate current (Moss and Mayes, 1993). Ostrand (2000) found abiotic factors associated with smalleye shiner habitat to include specific conductance 0.20 m/s)(0.65 feet/s) and high turbidity (> 41 NTU). Population dynamics modeling estimates a mean summer water discharge of approximately 2.61 m3s-1 (92 cfs) is necessary to sustain populations of sharpnose shiners (Durham 2007, p. 110) (Durham and Wilde 2009b, p. 670). Sharpnose shiners, like other native fishes of the upper Brazos River, are relatively tolerant of high temperature, high salinity, high turbidity, and low dissolved oxygen (DO) (Table 1; Service 2014, Chapter 2.B.2. Physiological Tolerances). However, abiotically induced mortality resulting from low DO in isolated pools (a natural occurrence) is known to occur, and mortality may also occur from naturally occurring salt plumes. The best available science suggests the primary needs of sharpnose populations include unobstructed, wide, flat-bottom, flowing river segments of greater than 275 km (171 mi) in length to support development of their early life history stages.(USFWS, 2015; NatureServe, 2015)

Dispersal/Migration

Motility/Mobility

Adult: High (USFWS, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Not available.

Population Information and Trends

Population Trends:

Long-term trends suggest a decline of 5-70% and shor-term trends indicate a decline of <30% to relatively stable population (NatureServe, 2015)

Resiliency:

Over longer terms greater than a few years, both species have naturally limited resiliency because their life span is usually 2 years or less. Therefore, impoundments and other stressors (such as groundwater withdrawals) affect the flow regime to the extent that the minimum streamflows necessary for successful reproduction and population growth in these species may not be maintained. As a result, any stressors in the upper Brazos River basin precluding successful reproduction that persist over two successive spawning seasons will not only affect individuals, but would likely lead to complete population extirpation. Since there is only one extant viable population remaining for both smalleye and sharpnose shiner, this would also result in species extinction. The potential for this kind of extinction event is heightened by climate change, which has increased the probability of severe droughts in this region. The resiliency of these species (the ability to withstand randomly occurring events of varying magnitude and duration) is limited because fish barriers restrict their ability to migrate from drought conditions and recolonize river segments upon return of favorable conditions (USFWS, 2014).

Representation:

Sharpnose and smalleye shiners lack the representation (the ability of to adapt to changing environmental conditions) necessary to overcome the impacts of habitat fragmentation and loss of river flow because it would likely require adapting their reproductive strategy. The evolution of a different reproductive strategy (away from broadcast spawning) or the extensive adaption of their existing strategy (e.g., by increasing egg/larval development rate) would not be expected to occur within a time period rapid enough to avoid being overcome by their threats (USFWS, 2014).

Redundancy:

Currently sharpnose and smalleye shiners are each essentially restricted to single populations in the upper Brazos River upstream of Possum Kingdom Lake, due primarily to habitat fragmentation and flow regime alteration in other river segments where they historically occurred but have been extirpated. Although a small number of fish were released into the lower Brazos River in 2012, these populations are likely either functionally or completely extirpated. Due to the existence of only a single population of each species in the upper Brazos River basin, all of the potential effects to this population also serve to affect the species as a whole and place the entire species at risk of extinction. Therefore, both the sharpnose and smalleye shiner currently have no redundancy (i.e., multiple populations) by which to survive a catastrophic event in the upper Brazos River basin. Any future event or action that extirpates the populations in the upper Brazos River basin would result in the extinction of the species. Future events similar to the severe drought conditions in 2011 that resulted in a complete lack of successful reproductive effort and juvenile recruitment in both species (Wilde 2012b, pers. comm.), may expose the entire range of both species to risk of complete loss. Given these species generally only survive through two reproductive seasons, back-to-back severe drought years could result in their extinction from inadequate flows without human intervention (USFWS, 2014).

Number of Populations:

1 (NatureServe, 2015)

Population Size:

10,000 - 1,000,000 individuals (NatureServe, 2015)

Additional Population-level Information:

With only one isolated population of each species remaining, these species have no redundancy, reduced resiliency due to the inability to disperse downstream, and limited representation. Therefore, these species are in danger of extinction from only one adverse event (such as lack of river flow for two consecutive years). The severe range reduction and isolation of these species to a single population in the upper Brazos River reduces the likelihood of their survival, which is exacerbated by the ongoing and intensifying effects of river fragmentation, climate change induced drought, saltcedar encroachment, water quality degradation, and commercial bait harvesting.

Population Narrative:

Long-term trends suggest a decline of 5-70% and shor-term trends indicate a decline of <30% to relatively stable population. Total adult population size is unknown (USFWS 2011) but likely exceeds 10,000. Extensive sampling at thirteen sites within the Upper Brazos by Ostrand (2000) in 1997 and 1998 produced 2,791 sharpnose shiners at 10 sites (Garza, Kent, Fisher, Stonewall, and Knox counties), where they represented one of the seven dominant species. The population of sharpnose shiners upstream from Possum Kingdom Reservoir is estimated to represent 8% of the fish assemblage (Ostrand 2000). With only one isolated population of each species remaining, these species have no redundancy, reduced resiliency due to the inability to disperse downstream, and limited representation. Therefore, these species are in danger of extinction from only one adverse event (such as lack of river flow for two consecutive years). The severe range reduction and isolation of these species to a single population in the upper Brazos River reduces the likelihood of their survival, which is exacerbated by the ongoing and intensifying effects of river fragmentation, climate change induced drought, saltcedar encroachment, water quality degradation, and commercial bait harvesting. Short lifespans limit their ability to withstand stochastic events affecting reproductive ability for two or more consecutive years. Sharpnose and smalleye shiners are each restricted to single populations within the upper Brazos River. Sharpnose and smalleye shiners lack the genetic representation necessary to overcome the impacts of habitat fragmentation and loss of river flow because it would require the complete evolution of a different reproductive strategy (away from broadcast spawning). (NatureServe, 2015)

Threats and Stressors

Stressor: Reservoir development (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Reservoir development within the Brazos River Basin is largely responsible for the modification of habitat in the river that has rendered major portions unsuitable for the sharpnose shiner. The three major impoundments of the Brazos River proper have apparently extirpated the sharpnose shiner from the middle Brazos region and reduced it to relict populations within the lower portion of the river. Proposed reservoir development in the upper

Brazos region is a significant threat to the extant populations. While only one reservoir is currently permitted (Post Reservoir) in the upper Brazos region, others are included in the Texas State Water Plan as a potential source to meet the demand for water through the year 2060. (NatureServe, 2015)

Stressor: Mining, industrial and municipal discharge, cattle feedlot operations (CAFOs), desalination, sedimentation, and saltcedar (NatureServe, 2015)
Exposure:
Response:
Consequence:
Narrative: Additional substantial threats to the sharpnose shiner are in-stream sand and gravel mining, industrial and municipal discharges, CAFOs, desalination, excessive sedimentation, and the spread of invasive saltcedar. The effect of saltcedar within the upper Brazos region threatens the existing sharpnose shiner habitat. Saltcedar encroachment in the upper Brazos and tributaries is likely an indirect result of impoundment of the river. Desalination is a potential future threat in the upper Brazos River Basin. In-stream sand and gravel mining, excessive sedimentation, and industrial and municipal discharges coupled with the effect of impoundments, reduce the likelihood of the Brazos River sustaining viable populations of the sharpnose shiner downstream of Possum Kingdom Reservoir. These threats combined with the substantial reduction in historic range due to anthropogenic factors justify the candidate status of the sharpnose shiner. (NatureServe, 2015)

Stressor: River fragmentation (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: The two primary factors affecting the current and future conditions of these shiners are river fragmentation by impoundments and alterations of the natural streamflow regime (by impoundments, drought, groundwater withdrawal, and saltcedar encroachment). (USFWS, 2015)

Stressor: Habitat loss (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Significant reduction of the amount of suitable habitat reduces carrying capacity for remaining populations and reduces habitat available for successful reproduction. (USFWS, 2015)

Stressor: Reduction/alteration of stream flow (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Reduction/Alteration of stream flow – alterations in the flow regime can negatively affect shiner survivability and reproduction. Sources of reduced/altered stream flow – impoundments, drought, groundwater withdrawal, saltcedar encroachment, in-channel projects that affect channel morphology.

Stressor: Water quality degradation (USFWS, 2015)
Exposure:

Response:
Consequence:
Narrative: Significant reduction of water quality results in mortality of individuals and has the potential to affect these shiners at the population and species level during periods of drought and range restriction. Point source pollution – pollution results in mortality of fish and may have sub-lethal affects (although this requires further examination). Pollution has the potential to affect these shiners at the population and species level during periods of drought and range restriction. Toxic golden alga blooms – toxic golden alga blooms result in mortality of fish and have the potential to affect these shiners at the population and species level during periods of drought and range restriction. (USFWS, 2015)

Stressor: Commercial bait harvesting (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: The removal of individuals from the wild to be sold as bait reduces the number of fish in the remaining populations of these species and has the potential to affect these shiners at the population and species level during periods of drought and range restriction. (USFWS, 2015)

Recovery

Reclassification Criteria:
Objective 1. Improve current population. Criteria. Ensure existing population is resilient within 50 years and annual reproduction indicates young-of-year in the upper Brazos management units (MUs) for five consecutive years (USFWS, 2022).

Objective 2: 2. Create captive population. Criteria: Establish captive population to augment current population (USFWS, 2022)

Objective 3. Ensure adequate stream flow, Criteria: a) Ensure sufficient base flows in the upper Brazos MUs to sustain species. b) Ensure recruitment flows within upper Brazos MUs allow for population growth rate necessary for viability (USFWS, 2022).

Objective 4. Improve water quality. Criteria: a) Protect water quality and maintain contaminant concentrations below thresholds that cause acute or chronic toxicity to shiners or their prey in upper Brazos MUs. b) Ensure hazardous material spills are avoided or managed through containment, spill response capability, and other best management practices in upper Brazos MUs within 50 years. c) Remove, relocate, or remediate wastewater flows discharged to upper Brazos MUs that are harmful to shiners to protect water quality (USFWS, 2022).

Objective: 5. Restore river morphology. Criteria: a) Ensure stream segments exist in upper Brazos MUs that allow connectivity and free movement of all life stages. b) Maintain or restore stream width and substrate. c) Reduce salt cedar to < 10% of current occupied range (USFWS, 2022).

Delisting Criteria:
Criteria: 6. Ensure presence of two populations (USFWS, 2022)

Objective: 7. Ensure habitat supports both populations. Criteria: a) Ensure base flows within occupied habitat sufficient for survival rate to achieve Criterion 6. b) Ensure sufficient recruitment flows to generate population growth to achieve Criterion 6. c) Ensure water quality is adequate to support survival rates to achieve Criterion 6. d) Ensure sufficient quantity and quality of stream morphology for recruitment and survival rates that meet Criterion 6. (USFWS, 2022)

Recovery Actions:

- Establish partnerships to manage and control saltcedar encroachment along the riparian corridor of occupied areas of the upper Brazos River basin. (USFWS, 2015)
- Work with the Service's Fisheries Program, TPWD, and other knowledgeable entities to determine what types of road crossings are best designed to allow for water and fish passage and are stable in the arid prairie stream environment. (USFWS, 2015)
- Identify captive propagation requirements and develop a protocol for large-scale captive breeding. (USFWS, 2015)
- Work with TPWD and the scientific community to develop a protocol for the release of captive bred individuals into occupied and historically occupied reaches for research and monitoring purposes and to provide population redundancy (even if just temporarily due to habitat unsuitability). (USFWS, 2015)
- Work with stakeholders to determine the source of pollution discharges negatively affecting shiners and to take steps to avoid and minimize future surface water contamination. (USFWS, 2015)
- Work with stakeholders to remove existing fish migration barriers (including impoundments) if they are no longer useful or in service. (USFWS, 2015)
- Work with stakeholders to implement water release strategies to aid fish reproduction during the spawning season. (USFWS, 2015)
- Work with stakeholders to implement groundwater and surface water conservation strategies in the upper Brazos River basin to maximize surface water flows. (USFWS, 2015)
- Evaluate the causes of golden alga blooms, their extent, and impacts to shiners in the upper Brazos River basin. (USFWS, 2015)
- Refine estimates of required stream length and required minimum stream flow for reproductive purposes. (USFWS, 2015)
- Conservation measures are not available.
- Recovery Priority Number: 5C

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Based on the threats evaluated and reduced range and reproductive strategy of these species, the SSA Report provides a chapter on conservation opportunities. These opportunities are summarized here: Improve redundancy and resiliency – Both species exist in only a single suitable river segment (the upper Brazos River) within the historical distribution. Redundancy may need to be addressed through a number of alternative means. Three possible means of increasing redundancy in these species are (1) a captive propagation and/or refugia program to ensure that the species are not lost due to catastrophic loss of their only populations; (2) reintroducing these species within their historical ranges and monitoring to determine their success and if minimum requirements have been correctly assessed; and (3) removal of existing fish barriers and restoration of the Brazos River, where feasible and appropriate, to provide additional river length and suitable stream flow in which sharpnose and smalleye shiners could seek refuge from severe droughts and other catastrophic events. Minimize impacts from impoundments - Despite planning and managing to accommodate the needs of sharpnose and smalleye shiners to the greatest extent possible, future reservoirs within the upper Brazos River basin will negatively impact these species. Depending on the location, design, and management of future reservoirs within the upper Brazos River basin, expected impacts would include at least one or more of the following: decreased water volume in occupied sections of the river, fragmentation or shortening of occupied river segments, changes in water quality, conversion of occupied riverine habitat to lentic habitat, alteration of river channel substrate and sediment transport, altered hydraulic habitat, or alteration of the natural flow regime. Although siting, design, and management of future reservoirs in the upper Brazos River basin could be realized in a way that may reduce adverse impacts to sharpnose and smalleye shiners, the restricted range and current status of these species makes them vulnerable to even slight changes to their remaining occupied habitat. Minimizing impacts could include: 1) adopting rigorous water conservation strategies; 2) implementing water releases from new and existing reservoirs that provide a minimum mean discharge exceeding 227 cubic feet/second in occupied downstream habitat during the spawning season (April – Sept); 3) adopting flow recommendations from the Brazos River Basin and Bay Expert Science Team Report (BBEST 2012); and 4) designing future impoundments to avoid releasing hypolimnetic water that is not representative of the upstream water. Minimize impacts from saltcedar encroachment - Saltcedar control efforts should be concentrated on dense stands that can be replaced by native vegetation with a lower leaf area—potentially including native forbs, grasses, and cottonwood trees—to maximize the potential for water salvage without eliminating important riparian vegetation communities (Shafroth et al. 2005, p. 240). The salvage of any groundwater or surface water runoff that can elevate streamflow within occupied shiner habitat would benefit these species by supporting necessary flows for survival and successful reproduction. Chemical control of saltcedar is typically performed using imazapyr-based compounds, which are unlikely to be toxic to fish or aquatic invertebrates (USEPA 2006, pp. 17– 18; BASF 2012a, p. 2; BASF 2012b, p. 2). Implement general water conservation strategies - Improvements to agricultural, municipal, and industrial water use efficiency would decrease water demand and put less pressure on the already strained surface and groundwater resources of the upper Brazos River basin. These conservation measures (including but not limited to the use of high-efficiency household appliances and fixtures, optimization of commercial and industrial water uses, and improved irrigation efficiencies for agriculture) could reduce the need for additional reservoir development, increase groundwater contribution to streamflow, and allow existing reservoirs to release more stormwater runoff than occurs currently. These benefits from general water conservation would likely increase streamflow within occupied sharpnose and smalleye shiner habitat, improving their likelihood for survival and successful reproduction. Conserve native vegetation adjacent to occupied habitat - Riparian vegetation adjacent to riverine habitat filters surface water runoff and is important in maintaining instream water quality. The ability of riparian buffers to filter surface runoff is largely dependent on vegetation density, type, and slope, with dense, grassy vegetation and gentle slopes facilitating filtration. Due to a lack of dense, grassy vegetation throughout much of the designated critical habitat, a 30-m (98-ft) buffer may be most appropriate to maintain proper runoff filtration (Fischer and Fischenich 2000, p. 8). Conservation of native riparian vegetation along the banks of occupied sharpnose and smalleye shiner river segments is not generally expected to negatively impact farming or ranching activities, nor would it require restricting landowner access to these buffer areas. Allowing cattle access to the river might help remove vegetation that would otherwise have been removed by seasonal floods that are now reduced by upstream impoundments, thereby reducing the likelihood occupied river segments will become further channelized by encroaching vegetation. Regardless, there is no scientific evidence suggesting cattle access to occupied river segments or the riparian buffers is currently a threat to either sharpnose or smalleye shiners. (USFWS, 2021)

- Scenario 1 – Upper Brazos River Basin Restoration Under this scenario, groundwater extraction and climatic conditions influencing the sharpnose shiner population continue at current rates. These effects are already occurring, resulting in reduced streamflow throughout the upper Brazos River basin since the 1940s based on USGS streamflow data (source: https://waterdata.usgs.gov). To offset these sources of stream flow loss, targeted restoration actions implemented throughout the upper Brazos River basin would be necessary. Restoration actions would include the following: 1) removal of invasive species (e.g., saltcedar); 2) restoration of native stream bank plant communities; 3) protection of water quality, outreach to stakeholders, and enhanced TPDES permit review for proposed wastewater discharges to the upper Brazos River; 4) water release strategies to aid fish reproduction/recruitment during the spawning season; 5) restoration of fish passage upstream of Possum Kingdom Reservoir through removal of barriers; and 6) implementation of groundwater and surface water management strategies in the upper Brazos River basin to provide adequate surface water flows. (USFWS, 2018)

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SPECIES ACCOUNT: *Notropis simus pecosensis* (Pecos bluntnose shiner)

Species Taxonomic and Listing Information

Listing Status: Threatened; 02/20/1987; Southwest Region (Region 2) (USFWS, 2016)

Physical Description

Notropis simus pecosensis is a moderate-sized shiner separable from co-occurring shiners by its robust body, blunt and rounded snout, and large, slightly subterminal mouth that usually extends even with the pupil. The eye is relatively small and the caudal peduncle comparatively deep (Sublette et al. 1990). Pharyngeal dentition is usually 2,4—4,2 (Chernoff et al. 1982); anal fin rays number 8—10, with a mode of 9; and lateral—line scales number 33—38. The Pecos bluntnose shiner may attain a total length (TL) of 90 mm (63 mm standard length [SLJ). The species is pallid gray to greenish-brown dorsally and whitish ventrally. A wide, silvery lateral stripe (dusky in preserved specimens) extends from the pectoral girdle to the caudal base. Pelvic and anal fins lack pigmentation, dorsal and pectoral fins have small black flecks along rays, and the caudal fin is variably pigmented (Chernoff et al., 1982). (USFWS, 1992)

Taxonomy

Jordan and Gilbert (1883) assigned the species to the genus Cliola, but Evermann and Kendall (1894) placed it in Notronis. Koster (1957) believed a similar, undescribed species occupied the Pecos River in New Mexico. Chernoff et al. (1982) described the Pecos form as a new subspecies, Notropis simus pecosensis, and distinguished it from the nominate subspecies, N. s. simus, the Rio Grande form. Chernoff et al. (1982) demonstrated that Notropis orca is a valid species. (USFWS, 1992)

Historical Range

This species was first collected in 1874 from the Rio Grande near San Ildefonso, New Mexico; Pecos River drainage of eastern New Mexico, just south of Santa Rosa to Carlsbad (Chernoff et al. 1982). (NatureServe, 2015)

Current Range

Currently, Pecos River from Fort Sumner to Artesia, a distance of 175 miles, in De Baca, Chaves, and Eddy counties, New Mexico (Hatch et al. 1985). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 2/20/1987.

Legal Description

On February 20, 1987, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Notropis simus pecosensis (Pecos bluntnose shiner) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes two critical habitat units (CHUs) in New Mexico and Texas (52 FR 5295-5303).

Critical Habitat Designation

The critical habitat designation for Notropis simus pecosensis includes two CHUs in De Baca, Chaves and Eddy Counties, New Mexico (52 FR 5295-5303).

New Mexico: De Baca and Chaves Counties. Pecos River from point at the north boundary of NE ¼ Sec. 2; T1N; R26E (approximately 10 mi. (16 km.) south of Fort Sumner) extending downstream approximately 64 mi. (103 km.) to a point at the south boundary SW ¼ Sec. 35; T5S; R25W.

New Mexico. Chaves and Eddy Counties. Pecos River from the west boundary NW ¼ Sec. 7; T14S; R27E. extending downstream approximately 37 mi. (60 km.) to the NW ¼ Sec. 18; T17S; R27E (to the U.S. highway 82 bridge near Astoria).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs for Notropis simus pecosensis in New Mexico are not specified but are assumed to be the following (52 FR 35034-35041):

Constituent elements include clean, permanent water: a main river channel habitat with sandy substrate; and a low velocity flow.

Life History

Feeding Narrative

Adult: Although Platania (1993) found both animal and vegetable matter within Pecos bluntnose shiner intestines, it is possible that vegetation is ingested incidental to prey capture. It is uncertain whether vegetation can be digested in such a short intestine (Hubbs and Cooper 1936, Marshall 1947). Young Pecos bluntnose shiners likely consume zooplankton primarily, while Pecos bluntnose shiners of increasing size rely upon terrestrial and aquatic insects (Platania 1993, Propst 1999). In a cursory analysis of 655 Pecos bluntnose shiner stomachs, Platania (1993) found terrestrial insects (ants and wasps), aquatic invertebrates (mainly fly larvae and pupae), larval fish, and plant seeds (salt cedar). Other studies have also documented Notropis species consuming seeds during winter (Minckley 1963, Whitaker 1977) and it could be that Pecos bluntnose shiners are primarily carnivorous, but utilize less favorable forage such as seeds when animal prey is scarce or that they indiscriminately ingest anything that is of the appropriate size. The Pecos bluntnose shiner’s diet is indicative of drift foraging (a feeding strategy where individuals wait in a favorable position and capture potential food items as they float by) (Starrett 1950, Griffith 1974, Mendelson 1975). Drift foragers depend upon frequent delivery of food to offset the energy required to maintain a position in the current (Fausch and White 1981). Water velocity must be adequate to deliver drift (Mundie 1969, Chapman and Bjornn 1969) but also of low enough speed to form refugia where the fish can rest within striking distance of target items (Fausch and White 1981, Fausch 1984). (USFWS, 2010)

Reproduction Narrative

Adult: The Pecos bluntnose shiner is a member of the pelagic spawning minnow guild found in large plains rivers (Platania 1995a, Platania and Altenbach 1998). These minnows release non-adhesive, semi-buoyant eggs that float in the water column (Platania and Altenbach 1998). Because these minnows inhabit large sand bed rivers where the substrate is constantly moving, semi-buoyant eggs are a unique adaptation to prevent burial (and subsequent suffocation) and abrasion by the sand (Bestgen et al. 1989). The spawning season extends from late April through September, with the primary period occurring from June to August (Platania 1993, 1995a). Spawning is cued by substantial increases in discharge, including flash floods and block releases of water (Platania 1993, Dudley and Platania 1999). Fecundity varies among individuals. Platania (1993) found that females released an average of 370 eggs with each spawning event and spawned multiple times during the spawning season. Because the eggs are semi-buoyant, they are carried downstream in the current (Platania 1993, 1995a, Platania and Altenbach 1998). Newly-hatched larvae float downstream for another two to four days. As the larvae drift, they “swim up”, a behavior in which they repeat a cycle of swimming toward the surface perpendicular to the current, sinking to the bottom, and upon touching substrate, propelling themselves back toward the surface (Platania 1993). This behavior allows larvae to remain within the water column and avoid burial by mobile substrate (Platania and Altenbach 1998). (USFWS, 2010)

Geographic or Habitat Restraints or Barriers

Adult: Studies have shown that Pecos bluntnose shiner avoid (or perish within) areas subjected to frequent surface flow intermittence (Hatch et al. 1985, Brooks et al. 1991, Hoagstrom et al. 2007, Davenport 2008a, Hoagstrom et al. 2008). Researchers determined that runs, flat-water areas, and pools with low or no velocity were avoided by the Pecos bluntnose shiner (Kehmeier et al. 2007). (USFWS, 2010)

Environmental Specificity

Adult: Medium (NatureServe, 2015)

Habitat Narrative

Adult: Pecos bluntnose shiners are typically found in the main river channel (especially after age II), often below obstructions, over substrate of sand, gravel, and silt. The Pecos bluntnose shiner is a habitat specialist preferring mid-channel plunge-pool habitats. Apparently dependent on large flows (Chernoff et al. 1982). Often over sandy bottom in area of low velocity laminar flow at depths of 17-41 cm (Hatch et al. 1985). Young have been found in backwaters, riffles, and pools. Natural springs such as those in the Santa Rosa and Lake McMillan areas support small populations (Matthews and Moseley 1990). Reproduction is limited to two perennial sections with local groundwater seepage (Hatch et al. 1985). There was a distinct trend in velocity with age-0 fish found primarily in velocities less than 20 cm per second and age 1 and 2 fish found primarily in velocities greater than 22 cm per second. Studies have shown that Pecos bluntnose shiner avoid (or perish within) areas subjected to frequent surface flow intermittence (Hatch et al. 1985, Brooks et al. 1991, Hoagstrom et al. 2007, Davenport 2008a, Hoagstrom et al. 2008). Researchers determined that runs, flat-water areas, and pools with low or no velocity were avoided by the Pecos bluntnose shiner (Kehmeier et al. 2007). (NatureServe, 2015)

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Dispersal/Migration Narrative

Adult: Not available.

Population Information and Trends

Population Trends:
Unknown (NatureServe, 2015)

Number of Populations:
1 (USFWS, 2020)

Population Size:
1 - 1000 individuals (NatureServe, 2015)

Population Narrative:
Water resource management is the key to shiner persistence, and the management approaches are well understood and established. However, given the highly regulated system and significant consumptive use demands, a level of water resource management is necessary in perpetuity to ensure persistence of Pecos bluntnose shiner. With careful resource management measures, the shiner population should remain stable. In the event of a population crash, the Service maintains a captive stock of 500-1,000 individuals (annual rotation with wild-caught fish) at our Southwestern Native Aquatic Resource and Recovery Center in Dexter, New Mexico. This satisfies effective population size (Ne) and genetic integrity recommendations for the species (see Osborne and Turner 2006; Osborne and Turner 2009; and Osborne et al. 2010: entire). This is a routine measure and does not constitute an intensive management practice. (USFWS, 2020)

Threats and Stressors

Stressor: Dams (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: The construction of dams has had many adverse effects on the Pecos River ecosystem (Dudley and Platania 2007, Hoagstrom et al. 2007). Dams have many downstream effects on the physical and biological components of a stream ecosystem including habitat fragmentation, a reduction in lateral channel migration, channel scouring, blockage of fish passage, channel narrowing, changes in the riparian community, diminished peak flows, changes in the timing of high and low flows, and a loss of connectivity between the river and its flood plain (Williams and Wolman 1984, Sherrard and Erskine 1991, Collier et al. 1996, Power et al. 1996, Kondolf 1997, Friedman et al. 1998, Polzin and Rood 2000, Shields et al. 2000, Dudley and Platania 2007, Hoagstrom et al. 2007). In the case of a pelagic spawner (fertilized eggs float in the water column) such as the Pecos bluntnose shiner, reproductive products (eggs and larvae) may also be lost in the unsuitable habitat of a downstream reservoir (Dudley and Platania 2007). Six dams control the flow of the Pecos River in New Mexico. Operations of four of these (Santa Rosa, Sumner, Fort Sumner Irrigation Diversion Dam, Brantley) affect the Pecos bluntnose shiner. After Sumner Dam was completed in 1937, it prevented all movement between the Pecos bluntnose shiner populations above and below the dam. Pecos bluntnose shiner was last collected upstream from Sumner Dam in 1963 (Platania and Altenbach 1998). Sumner Dam also traps sediment that would maintain the sandy river bed that Pecos bluntnose shiner prefers. The release of sediment-free water leads to channel scour below the dam, creating unsuitable habitat

in the Tailwaters Reach where the species has not been collected since 1999 (Kondolf 1997, Service 2003a, Davenport 2008b). (USFWS, 2010)

Stressor: Alteration of hydrology (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Maintaining a natural flow regime in managed rivers is considered important to conserving the native fauna of the aquatic ecosystem (Poff et al. 1997, Bunn and Arthington 2002, Richter et al. 2003). The flow regime of the Pecos River is highly modified and does not mimic natural conditions. Operation of Sumner Dam significantly alters flow regimes in the reach of river occupied by the Pecos bluntnose shiner (Service 1992, Tetra Tech 2000, Mussetter Engineering 2004). The effect of upstream water storage and diversion on the downstream reaches of the Pecos River is to reduce the frequency and magnitude of floods and reduce winter and summer flows (Service 2006). The construction of Sumner Dam reduced the 100-year peak flow below Sumner Dam from 43,100 cfs (1,220 m3/s) to 22,800 cfs (645 m3/s). The construction of Santa Rosa Dam caused an additional reduction peak flows to the current 100-year peak of 1,620 cfs (46 m3/s) (Mussetter Engineering 2004). Similar decreases are seen for all other return intervals of peak flows and at all of the downstream gauges (Mussetter Engineering 2004). Reduced peak discharge has caused the channel to become narrower and less braided, and to have less complex fish habitat (Tashjian 1993, 1994, 1995, 1997; Hoagstrom 2000, 2001, 2002). Large floods are an important component of riverine ecosystems because they maintain channel width and complexity, limit colonization of non-native vegetation, maintain native riparian vegetation, recharge the alluvial aquifer, increase nutrient cycling, and maintain the connection between the aquatic and riparian ecosystems (Schiemer 1995, Ward and Stanford 1995, Power 1996, Shafroth 1999). One of the reasons that habitat in the Rangelands reach remains suitable for Pecos bluntnose shiner, is the presence of tributary streams that add sediment and monsoonal flood flows to the Pecos River below Sumner Dam. In addition to a reduction in the magnitude of flood flows, the flow regime of the Pecos River is also modified by “block releases.” The U. S. Bureau of Reclamation (Reclamation) diverts water to storage at Sumner Reservoir for the Carlsbad Project and then releases the stored water for the Carlsbad Irrigation District in “blocks” in which large amounts of water (usually a minimum of 1,000 cfs [28 m3/s]) are released, typically for a period of two weeks. Block releases provide a cue for spawning, help maintain channel morphology, and if timed correctly, can alleviate intermittency (Reclamation 2005). Block releases that occur during the spawning season from May through September transport semi-buoyant Pecos bluntnose shiner eggs and larvae out of the favorable habitat reach of the Rangelands, and into the less suitable Farmlands reach or Brantley Reservoir. The eggs require water velocity to remain suspended in the water column. In the reservoir, the eggs sink to the bottom and likely perish when they are covered with sediments and suffocate or are eaten by predators. Also, larval fish are likely eaten by predatory fish. (USFWS, 2010)

Stressor: Irrigation (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Up to 100 cfs (2.8 m3/s) is diverted from the Pecos River by FSID for delivery to agricultural fields from March 1 through October 31. Water can also be diverted for two, eight-day periods during the winter; however, this diversion is typically made in the two weeks prior to

the irrigation season (i.e., February 15 to March 1). Fort Sumner Irrigation District has no storage rights in the upstream reservoirs but is entitled to water rights that pre-date Sumner Dam construction. The water entitlement is based on a calculation made by the Office of the State Engineer from flow data collected every two weeks throughout the irrigation season. Reclamation releases water from Sumner Dam for FSID and the water travels 14 mi (23 km) downstream to the FSID Diversion Dam. Here the water is diverted into a main canal that is 15 mi (24 km) long and feeds smaller lateral canals. A drain canal collects seepage and runoff from the fields and carries these return flows back to the Pecos River between Old Fort Sumner Sate Park and the confluence of Taiban Creek. The return flows to the Pecos River may be up to half of the amount diverted. (USFWS, 2010)

Stressor: Competition (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: At low discharge, competition for space and forage is likely increased (Hoagstrom 1999). Concentration of species is most severe during intermittency because fishes must congregate in remnant pools. In such cases, it is likely that fishes that commonly inhabit still and stagnant waters (e.g., red shiner [Cyprinella lutrensis], western mosquitofish [Gambusia affinis]) gain a competitive advantage over fluvial species such as Pecos bluntnose shiner (Summerfelt and Minckley 1969, Cross et al. 1985). Ostrand and Wilde (2004) found that although cyprinids (including two species of shiner, N. buccula and N. oxyrhynchus) were the most abundant species when isolated pools first formed in the Brazos River, Texas, there was a significant decline in the abundance of sharpnose shiner and an absence of plains minnow, smalleye shiner, and red shiner from collections after six days of confinement in pools. They determined that intolerance to increases in salinity was the reason for the decline in the cyprinids. In addition, without flows to deliver food items, species dependent upon drift, such as the Pecos bluntnose shiner, are at a disadvantage (Mundie 1969). (USFWS, 2010)

Stressor: Introduced fish species (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Introduced fish species, including the plains minnow (Hybognathus placitus) and the Arkansas River shiner (Notropis girardi) are now established members of the Pecos River fish community. They are also part of the guild of pelagic spawners to which the Pecos bluntnose shiner belongs (Platania 1995a). As a result of these introductions, interspecific competition may be a factor in the reduction in Pecos bluntnose shiner abundance and distribution. Young fishes of these species also use low velocity backwater areas and may compete directly with young Pecos bluntnose shiners for space and food (if food is limited); however, competitive interactions among Pecos River fishes have not been studied. (USFWS, 2010)

Stressor: Predation (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Predators that occupy the most suitable Pecos bluntnose shiner habitat include the native longnose gar (Lepisosteus osseus), flathead catfish (Pylodictis olivaris), and green sunfish

(Lepomis cyanellus), and the non-native channel catfish (Ictalurus punctatus), white bass (Morone chrysops), and spotted bass (Micropterus punctulatus) (Larson and Propst 2000). When captured during surveys, the majority of these predators has been small (less than 100 mm (3.9 in)) (Larson and Propst 2000, Valdez et al. 2003). Thus, low abundance and small size suggest fish predation is not a major threat to the Pecos bluntnose shiner (Larson and Propst 2000). However, the impacts of predaceous fishes within intermittent pools have not been studied and it is possible that they feed on Pecos bluntnose shiner (Larson and Propst 2000). The increase in intermittent flow days in 2002-2003 may have increased the risk of predation on Pecos bluntnose shiner caught in pools. The reduction in intermittent flow days in 2004 to eight days, and none in 2005, reduced that risk of predation. By maintaining continuous flows, the degree of risk from predation should be reduced. Aerial and terrestrial piscivores may also threaten the Pecos bluntnose shiner. Many piscivorous birds are seasonally found at BLNWRMT and piscivorous mammals and reptiles are present along the river. Least terns are known to prey on shiner species in other rivers (Wilson et al. 1993, Schweitzer and Leslie 1996), but this has not been documented on the Pecos River. As with piscivorous fishes, impacts of non-aquatic predators (e.g. raccoons, skunks, coyotes) on the Pecos bluntnose shiner are likely most significant during surface flow intermittence, when fishes are confined and crowded in shallow water (Larimore et al. 1959). Larson and Propst (2004) reported that the tracks of several predators, including Great blue heron, raccoon, and coyote, were seen around isolated pools that occurred during river intermittency. (USFWS, 2010)

Stressor: Golden algae (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Fish kills caused by golden algae (Prymnesium parvum) have been documented in the Texas portion of the Pecos River since 1985 (James and de la Cruz 1989). From 1985-1989 it was estimated that more than two million fish had died in the Pecos River because of golden algae (James and de la Cruz 1989). Fish kills attributed to golden algae in the New Mexico portion of the Pecos River have been documented since 2002 (NMDGF 2007). These kills have occurred from Brantley Reservoir downstream. The activity of the toxin produced by the algae is inversely proportional to salt concentrations in the water with concentrations of 3-50 parts per thousand (ppt) being optimal for toxin production (Watson 2001). It is likely that increased salinization in the lower Pecos (Hoagstrom 2009) has contributed to the number of fish kills. Kehmeier et al. (2004) did not record any salinity values over 2.4 ppt in habitat occupied by Pecos bluntnose shiner in 2002 and 2003, and no fish kills have been recorded in the Pecos River upstream of Brantley Reservoir. However, the spread of the algae upstream over time, the increased potential for drought, salinization, and nutrient concentrations over time (discussed under climate change below) are reasons for concern. (USFWS, 2010)

Stressor: Climate change (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: According to the Intergovernmental Panel on Climate Change (IPCC 2007) “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.” Average Northern Hemisphere temperatures during the second half of the

20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1,300 years (IPCC 2007). It is very likely that over the past 50 years, cold days, cold nights, and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007). Data suggest that heat waves are occurring more often over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007). If climate change leads to intense, widespread or long-lasting drought, it is anticipated that conflict over the limited water available in the Pecos River will increase as agricultural and municipal demands increase. There are no regulatory mechanisms that address climate change. (USFWS, 2010)

Recovery

Reclassification Criteria:
Reclassification criteria are not available.

Delisting Criteria:
Delisting criteria are not available.

Recovery Actions:

- Monitor existing populations. (USFWS, 1992)
- Maintain and enhance existing populations. (USFWS, 1992)
- Reintroduce fish into historic habitats. (USFWS, 1992)
- Enforce statutes that protect existing populations and their habitats. (USFWS, 1992)
- Develop and implement public information program. (USFWS, 1992)
- The highest priority to facilitate recovery for the Pecos bluntnose shiner is maintaining a continuous river flow from the confluence of Taiban Creek to Brantley Reservoir. (USFWS, 2010)
- Revise the recovery plan so that threat assessments incorporate new information along with clearly defined recovery actions and measurable, threats-based criteria. During the recovery plan update process, evaluate the efficacy of including the entire reach of the Pecos River, from the confluence of Taiban Creek to Brantley Reservoir, as critical habitat. (USFWS, 2010)
- Continue habitat restoration projects that create favorable habitat for Pecos bluntnose shiner. (USFWS, 2010)
- Investigate whether hybridization between Pecos bluntnose shiner and other pelagic spawning fish is occurring. (USFWS, 2010)
- Determine the fate of the Pecos bluntnose shiner in the Farmlands reach. Do shiners perish or do they disperse upstream? (USFWS, 2010)
- Continue population monitoring. (USFWS, 2010)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Recommended future actions include the following: 1) continue ongoing research (being conducted by the Service and funded by Reclamation) into the dynamics of the downstream displacement of eggs and larvae that result from block release hydrology, and opportunities for improved upstream retention; 2) begin comprehensive research, including continuous monitoring, of water quality and nutrient dynamics within the mainstem Pecos River between Sumner and Brantley Reservoirs to assess potential effects to the shiner; 3) work with

Reclamation and other basin stakeholders to secure additional sources of in-stream water; and 4) finalize the establishment of the fish conservation pool at Santa Rosa Reservoir. (USFWS, 2020)

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SPECIES ACCOUNT: *Notropis topeka (=N. tristis)* (Topeka shiner)

Species Taxonomic and Listing Information

Listing Status: Endangered; 12/15/1998; Mountain-Prairie Region (R6); Experimental Population, Non-Essential; 07/17/2013; Great Lakes-Big Rivers Region (R3) (USFWS, 2015) Recommended for downlisting to threatened (2021a)

Physical Description

A 2-inch fish (shiner). From Cross (1967) and Pflieger (1975): Body stout and chubby; head short; barbels absent; mouth small and oblique; snout rounded and shorter than or about equal to eye diameter; upper jaw not reaching past front of eye; eyes moderately small; dorsal fin large, height more than one half the predorsal length of fish; front of dorsal fin base originating approximately over insertion of pelvic fins; dorsal and pelvic fins with 8 rays; anal fin with 7 (rarely 6 or 8) rays; usually 13 rays in pectoral fin; lateral line straight with 32-37 scales; intestine short with a single S-shaped loop; peritoneum silvery, sometimes with a few faint, dark speckles; throat teeth 4-4. Breeding males with tubercles over much of head, body, and on some rays of pectoral and dorsal fins, largest on snout and top of head; ripe female with minute tubercles on top of head. Coloration: back olive-yellow, back scales prominently dark-edged; dark stripe along midline of back broad and distinct ahead of dorsal fin, often indistinct or absent behind; sides silvery with well-defined dusky longitudinal stripe extending onto head, stripe not bordered above with light-colored zone; sides below lateral line and belly silvery-white; tail fin with wedge-shaped black spot at base, fins otherwise plain; breeding male with all fins orange-red, head and body tinged with orange. Typical length is 1.6-2.6 inches (4.1-6.6 cm), with males averaging larger than females. Young of the year are 20-40 mm long, yearlings 35-55 mm, and two year olds 47-64 mm (Cross 1967, Kerns, unpubl.) (NatureServe, 2015).

Taxonomy

The Topeka shiner was first described by C.H. Gilbert in 1884, using specimens captured from Shunganunga Creek, Shawnee County, Kansas (Gilbert 1884) (USFWS, 1997). Notropis topeka evidently is related to N. stramineus and is a member of the N. procne species-group (genetic data of Schmidt and Gold, Copeia 1995:1991-204) (NatureServe, 2015).

Historical Range

This species formerly was widespread in western tributaries of the Mississippi River, from central Missouri through Iowa to southern Minnesota, west to eastern South Dakota, western Nebraska, and western Kansas (Phillips et al. 1982, Vandel 1982, USFWS 2009; NatureServe, 2015).

Current Range

It has been extirpated in many localities but still occurs in all six states in its historical range. Most of the remaining occupied habitat is in South Dakota-Minnesota and Kansas (USFWS 2009; NatureServe, 2015). The Topeka shiner is known to occur in portions of South Dakota, Minnesota, Kansas, Iowa, Missouri, and Nebraska (USFWS, 2009). The States of South Dakota and Minnesota are now estimated to support 70 percent of the Topeka shiner’s range, but in 1998, these areas were previously thought to contain only 20 percent of the estimated range (Service 2018, p. 7). (USFWS, 2021a)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 7/27/2004.

Legal Description

On July 27, 2004, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Notropis topeka (Topeka shiner) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes five critical habitat units (CHUs) including 85 subunits in Iowa, Minnesota and Nebraska (69 FR 44736-44770).

Critical Habitat Designation

The critical habitat designation for Tiaroga cobitis includes five CHUs and 85 sub-units in Calhoun, Carroll, Dallas, Greene, Hamilton, Lyon, Osceola, Sac, Webster, and Wright Counties, Iowa; Lincoln, Murray, Nobles, Pipestone, and Rock Counties, Minnesota; and Madison County, Nebraska (69 FR 44736-44770).

Unit 1: North Raccoon River Watershed—Calhoun, Carroll, Dallas, Greene, Sac and Webster Counties, Iowa. (i) Reach 1a. Indian Creek from its confluence with the North Raccoon River (T87N, R35W, Sec. 24), upstream through T87N, R35W, Sec. 29. (ii) Reach 1b. Tributary to Indian Creek (Ditch 57), from their confluence (T87N, R35W, Sec. 23), upstream to the confluence with the outlet creek from Black Hawk Lake (T86N, R36W, Sec. 1). (iii) Reach 1c. Outlet Creek from Black Hawk Lake from its confluence with Ditch 57 (T86N, R36W, Sec. 1), upstream to lake outlet (T87N, R35W, Sec. 35). (iv) Reach 2a. Camp Creek from its confluence with the North Raccoon River (T86N, R34W, Sec. 7), upstream through T87N, R34W, Sec. 8. (v) Reach 2b. West Fork Camp Creek from its confluence with Camp Creek (T87N, R34W, Sec. 8), upstream through T88N, R34W, Sec. 32. (vi) Reach 3. Prairie Creek from its confluence with the North Raccoon River (T86N, R34W, Sec. 16), upstream through T87N, R34W, Sec. 35. (vii) Reach 4. Lake Creek from its confluence with the North Raccoon River (T86N, R34W, Sec. 23), upstream through T87N, R33W, Sec. 25. (viii) Reach 5. Purgatory Creek from its confluence with the North Raccoon River (T84N, R33W, Sec. 11), upstream through T86N, R32W, Sec. 17. (ix) Reach 6a. Cedar Creek from its confluence with the North Raccoon River (T85N, R32W, Sec. 33), upstream to the confluence of West Cedar Creek and East Cedar Creek (T87N, R31W, Sec. 31). (x) Reach 6b. West Cedar Creek from its confluence with East Cedar Creek (T87N, R31W, Sec. 31), upstream through T87N, R31W, Sec. 18. (xi) Reach 6c. East Cedar Creek from its confluence with West Cedar Creek (T87N, R31W, Sec. 31), upstream through T87N, R31W, Sec. 9. luence with the North Raccoon River (T84N, R31W, Sec. 33), upstream through T84N, R31W, Sec. 28. (xiii) Reach 8. Hardin Creek from its confluence with the North Raccoon River (T83N, R30W, Sec. 23), upstream through T85N, R31W, Sec. 27. (xiv) Reach 9a. Buttrick Creek from its confluence with the North Raccoon River (T83N, R30W, Sec. 26), upstream to the confluence of West Buttrick Creek and East Buttrick Creek (T84N, R30W, Sec. 25). (xv) Reach 9b. West Buttrick Creek, from its confluence with East Buttrick Creek (T84N, R30W, Sec. 25), upstream through T86N, R30W, Sec. 3. (xvi) Reach 9c. East Buttrick Creek, from its confluence with West Buttrick Creek (T84N, R30W, Sec. 25), upstream through T85N, R29W, Sec. 20. (xvii) Reach 10a. Elm Branch from its confluence with the North Raccoon River (T81N, R28W, Sec. 28), upstream to its confluence with Swan Lake Branch T81N, R28W, Sec. 28. (xviii) Reach 10b. Swan Lake Branch from its confluence with Elm Branch (T81N, R28W, Sec. 28), upstream through T80N, R28W, Sec. 4. (xix) Reach 11. Off-channel and sidechannel pools (that meet the previously described criteria) adjacent to the North Raccoon River from U.S. Highway 6 (T79N, R27W, Sec. 32), upstream to U.S. Highway 20 (T88N, R36W, Sec. 24).

Unit 2: Boone River Watershed— Wright and Hamilton Counties, Iowa. (i) Reach 12. Eagle Creek from its confluence with the Boone River (T89N, R25W, Sec. 6), upstream through T91N, R25W, Sec. 30. Ditch 3 and Ditch 19 Complex (ii) Reach 13a. Ditch 3 from its confluence with the Boone River (T91N, R26W, Sec. 32), upstream through T91N, R26W, Sec. 30. (iii) Reach 13b. Ditch 19 from its confluence with Ditch 3 (T91N, R26W, Sec. 31), upstream through T91N, R26W, Sec. 31.

9) Unit 3: Rock River Watershed— Lyon and Osceola Counties, Iowa. Rock River Complex (i) Reach 14. Rock River from its confluence with Kanaranzi Creek (T100N, R45W, Sec. 28), upstream to the Iowa/Minnesota State border (T100N, R45W, Sec. 8). (ii) Reach 15. Kanaranzi Creek from its confluence with the Rock River (T100N, R45W, Sec. 28), upstream to the Iowa/Minnesota State border (T100N, R45W, Sec. 11). Little Rock River Complex (iii) Reach 16. Little Rock River from State Highway 9 (T100N, R43W, Sec. 34), upstream to the Iowa/Minnesota State border (T100N, R42W, Sec. 7).

Unit 4: Big Sioux River Watershed—Lincoln, Pipestone and Rock, Counties, Minnesota; and Rock River Watershed—Murray, Nobles, Pipestone and Rock Counties, Minnesota. Medary Creek Complex (i) Reach 1a. Medary Creek from the Minnesota/South Dakota State border (T109N, R47W, Sec. 13), upstream through T110N, R46W, Sec. 21. (ii) Reach 1b. Unnamed tributary to Medary Creek, from their confluence (T109N, R46W, Sec. 18), upstream through T110N, R46W, Sec. 30. Flandreau Creek Complex (iii) Reach 2a. Flandreau Creek from the Minnesota/South Dakota State border (T107N, R47W, Sec. 14), upstream through T109N, R45W, Sec. 31. (iv) Reach 2b. Unnamed tributary to Flandreau Creek, from their confluence (T108N, R46W, Sec. 11), upstream through T108N, R45W, Sec. 6. (v) Reach 2c. East Branch Flandreau Creek from its confluence with Flandreau Creek (T108N, R46W, Sec. 14), upstream through T108N, R45W, Sec. 4. (vi) Reach 2d. Willow Creek from its confluence with Flandreau Creek (T107N, R46W, Sec. 6), upstream through T108N, R46W, Sec. 3. Split Rock/Pipestone/Beaver Creek Complex (vii) Reach 3a. Pipestone Creek from the Minnesota/South Dakota State border (T106N, R47W, Sec. 23), upstream through T106N, R46W, Sec. 1. (viii) Reach 3b. Unnamed tributary to Pipestone Creek, from their confluence (T106N, R47W, Sec. 24), upstream through T106N, R46W, Sec. 19. (ix) Reach 3c. Unnamed tributary to Pipestone Creek, from the Minnesota/ South Dakota State border (T105N, R47W, Sec. 2), upstream through T105N, R46W, Sec. 1. (x) Reach 3d. North Branch Pipestone Creek from its confluence with Pipestone Creek (T106N, R46W, Sec. 5), upstream through T107N, R45W, Sec. 4. (xi) Reach 3e. Unnamed tributary to North Branch Pipestone Creek, from their confluence (T107N, R45W, Sec. 4), upstream through T108N, R45W, Sec. 23. (xii) Reach 3f. Split Rock Creek from the Minnesota/South Dakota State border (T103N, R47W, Sec. 2), upstream to Split Rock Lake Outlet (T105N, R46W, Sec. 22). (xiii) Reach 3g. Unnamed tributary to Split Rock Creek from the Minnesota/ South Dakota State border (T103N, R47W, Sec. 23), upstream through T103N, R46W, Sec. 29. (xiv) Reach 3h. Unnamed tributary to Split Rock Creek, from their confluence (T103N, R47W, Sec. 2), upstream through T103N, R46W, Sec. 8. (xv) Reach 3i. Unnamed tributary to Split Rock Creek, from their confluence (T104N, R47W, Sec. 25), upstream through T104N, R46W, Sec. 19. (xvi) Reach 3j. Pipestone Creek from its confluence with Split Rock Creek (T104N, R47W, Sec. 22), upstream to the Minnesota/South Dakota State border T104N, R47W, Sec. 23. (xvii) Reach 3k. Unnamed tributary to Split Rock Creek, from their confluence (T104N, R46W, Sec. 6), upstream through T105N, R46W, Sec. 36.

(xviii) Reach 3l. Split Rock Creek from the headwater of Split Rock Lake (T105N, R46W, Sec. 15), upstream through T106N, R46W, Sec. 35. (xix) Reach 3m. Unnamed tributary to Split Rock Creek, from their confluence (T105N, R46W, Sec. 3), upstream through T105N, R46W, Sec. 2. (xx) Reach 3n. Beaver Creek from the Minnesota/South Dakota State border (T102N, R47W, Sec. 34), upstream through T104N, R45W, Sec. 20. (xxi) Reach 3o. Springwater Creek from its confluence with Beaver Creek (T102N, R47W, Sec. 34), upstream through T102N, R46W, Sec. 6. (xxii) Reach 3p. Little Beaver Creek from its confluence with Beaver Creek (T102N, R46W, Sec. 12), upstream through T103N, R45W, Sec. 9. (xxiii) Reach 3q. Unnamed tributary to Beaver Creek, from their confluence (T102N, R46W, Sec. 1), upstream through T103N, R46W, Sec. 35. (xxiv) Reach 3r. Unnamed tributary to Beaver Creek, from their confluence (T103N, R45W, Sec. 18), upstream through T104N, R46W, Sec. 36. Rock River Complex (xxv) Reach 4a. Rock River from the Minnesota/Iowa State border (T101N, R45W, Sec. 36), upstream through T107N, R44W, Sec. 7. (xxvi) Reach 4b. Kanaranzi Creek from the Minnesota/Iowa State border (T101N, R44W, Sec. 33), upstream through T103N, R42W, Sec. 7). (xxvii) Reach 4c. Norwegian Creek from its confluence with Kanaranzi Creek (T101N, R44W, Sec. 25), upstream through T101N, R43W, Sec. 21. (xxviii) Reach 4d. Unnamed tributary to Norwegian Creek, from their confluence (T101N, R44W, Sec. 20), upstream through T101N, R44W, Sec. 16. (xxix) Reach 4e. East Branch Kanaranzi Creek from its confluence with Kanaranzi Creek (T102N, R42W, Sec. 5), upstream through T102N, R41W, Sec. 5. (xxx) Reach 4f. Unnamed tributary to East Branch Kanaranzi Creek, from their confluence (T102N, R42W, Sec. 9), upstream through T102N, R42W, Sec. 22. (xxxi) Reach 4g. Unnamed tributary to East Branch Kanaranzi Creek, from their confluence (T102N, R42W, Sec. 5), upstream through T102N, R42W, Sec. 5. (xxxii) Reach 4h. Unnamed tributary to Kanaranzi Creek, from their confluence (T102N, R43W, Sec. 31), upstream through T102N, R43W, Sec. 27. (xxxiii) Reach 4i. Ash Creek from its confluence with the Rock River (T101N, R45W, Sec. 24), upstream through T101N, R45W, Sec. 14. (xxxiv) Reach 4j. Elk Creek from its confluence with the Rock River (T102N, R45W, Sec. 36), upstream through T103N, R43W, Sec. 22. (xxxv) Reach 4k. Unnamed tributary to Elk Creek, from their confluence (T102N, R44W, Sec. 16), upstream through T102N, R44W, Sec. 9. (xxxvi) Reach 4l. Champepadan Creek from its confluence with the Rock River (T103N, R44W, Sec. 29), upstream through T104N, R43W, Sec. 14. (xxxvii) Reach 4m. Unnamed tributary to Champepadan Creek, from their confluence (T104N, R43W, Sec. 14), upstream through T104N, R43W, Sec. 13. (xxxviii) Reach 4n. Unnamed tributary to Champepadan Creek, from their confluence (T103N, R44W, Sec. 23), upstream through T103N, R44W, Sec. 24. (xxxix) Reach 4o. 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Unit 5: Elkhorn River Watershed—Madison County, Nebraska. Taylor Creek from its confluence with Union Creek (T22N, R1W, Sec. 32), upstream through T22N, R2W, Sec. 22.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Tiaroga cobitis critical habitat consists of nine components in Iowa, Minnesota and Nebraska (69 FR 44736-44770):

(i) Streams most often with permanent flow, but that can become intermittent during dry periods.

(ii) Side-channel pools and oxbows either seasonally connected to a stream or maintained by groundwater inputs, at a surface elevation equal to or lower than the bank-full discharge stream elevation. The bankfull discharge is the flow at which water begins leaving the channel and flowing into the floodplain; this level is generally attained every 1 to 2 years. Bankfull discharge, while a function of the size of the stream, is a fairly constant feature related to the formation, maintenance, and dimensions of the stream channel.

(iii) Streams and side-channel pools with water quality necessary for unimpaired behavior, growth, and viability of all life stages. (The water quality components include— temperature, turbidity, conductivity, salinity, dissolved oxygen, pH, chemical contaminants, and other chemical characteristics.).

(iv) Living and spawning areas for adult Topeka shiner with pools or runs with water velocities less than 0.5 meters/second (approx. 20 inches/ second) and depths ranging from 0.1– 2.0 meters (approx. 4–80 inches).

(v) Living areas for juvenile Topeka shiner with water velocities less than 0.5 meters/second (approx. 20 inches/ second) with depths less than 0.25 meters (approx. 10 inches) and moderate amounts of instream aquatic cover, such as woody debris, overhanging terrestrial vegetation, and aquatic plants.

(vi) Sand, gravel, cobble, and silt substrates with amounts of fine sediment and substrate embeddedness that allow for nest building and maintenance of nests and eggs by native Lepomis sunfishes (green sunfish, orangespotted sunfish, longear sunfish) and Topeka shiner as necessary for reproduction, unimpaired behavior, growth, and viability of all life stages.

(vii) An adequate terrestrial, semiaquatic, and aquatic invertebrate food base that allows for unimpaired growth, reproduction, and survival of all life stages.

(viii) A hydrologic regime capable of forming, maintaining, or restoring the flow periodicity, channel morphology, fish community composition, offchannel habitats, and habitat components described in the other primary constituent elements.

(ix) Few or no nonnative predatory or nonnative competitive species present.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the areas determined to be essential for conservation may require special management considerations or protection. Primary threats and special management considerations are described below on a unit-by-unit basis (see Critical Habitat Unit Descriptions). Overall, major threats to this species include sedimentation caused by agricultural practices, ditch maintenance, and road construction, as described in the final listing rule. Measures to improve habitat include grass waterways, riparian fencing, and best management practices for construction projects and ditch maintenance (63 FR 69008).

Life History

Feeding Narrative

Adult: Eats midge larvae and other aquatic invertebrates (abundant silt, sand, and detritus in gut contents indicates substantial benthic feeding) (Kerns, unpubl.; Cross and Collins 1995); picked very small invertebrates from the water column in a lab study (Gorman, pers. comm.). It is most active during the day (Kerns, unpub.) (NatureServe, 2015). The Topeka shiner is an opportunistic omnivore, feeding on aquatic insects, microcrustaceans, larval fish, algae, and detritus (Hatch and Besaw 2001) (USFWS, 2009).

Reproduction Narrative

Adult: The male has a small territory around green sunfish (Lepomis cyanellus) or orange-spotted sunfish (L. humilis) nests. Spawning occurs over the sunfish nests. In central Missouri, breeding occurs from late May to mid-July (Pflieger 1975). Cross (1967) reported the reproductive season in Kansas as being from late June through August, whereas Kerns (unpubl.) noted reproductive activity in Kansas from late May through July. The normal life span does not exceed three years (NatureServe, 2015). Dahle (2001) found that the species is a multiple clutch spawner. Kerns and Bonneau (2002) reported that only 62 percent of age-1 females were mature, compared with 100 percent of age-2 females. (USFWS, 2009). The Topeka shiner is reported to spawn in pool habitats (USFWS, 1997).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Schooling (USFWS, 1997)

Environmental Specificity

Adult: Broad (infered from NatureServe, 2015)

Dependency on Other Individuals or Species for Habitat

Adult: Campostoma anomalum (NatureServe, 2015)

Habitat Narrative

Adult: This species typically inhabits quiet, open, permanent pools of small, clear, high-quality headwaters and creeks that drain upland prairie areas, including tiny spring-fed pools in headwater streams and larger streams (Gorman, pers. comm.). Streams that have been channelized or impounded or that drain cultivated fields generally are not suitable habitat (Schrank et al. 2001; Gorman, pers. comm.; Prophet, pers. comm.). Many occupied streams become intermittent in the summer but the pools are maintained by springs. Habitat includes off-channel sites in Minnesota and Iowa, (primarily cut-off channels and oxbows that are seasonally flooded (Hatch, pers. comm. 1999; Menzel, Iowa State University, pers. comm. 1999); these sites likely connect with the water table, which probably keep temperature and dissolved oxygen concentrations within tolerance levels during hot, dry periods and prevent total freeze-out of pools in winter. Streams may or may not be bordered by trees (Gorman, pers. comm.). Riffles are occupied only if shiners are exceptionally abundant in a local area (Minckley and Cross 1959). Pool substrate is gravel, rubble, or sand, often with a slight silt layer (Kerns, unpublished data); usually does not occur in pools with large amounts of silt on the bottom (Minckley and Cross 1959), but in the South Fork of the Cottonwood River, Kansas, the larger pools containing Topeka shiners had several centimeters of silt (Kerns, unpublished data). The pools usually do not have rooted aquatic vegetation but many have plankton blooms during the summer (Minckley and Cross 1959; Kerns, unpublished data). In Kansas streams, the Topeka shiner is pelagic, occupying the lower half of the water column (Kerns, unpublished data), though Tabor (1993) stated that this fish occurs in mid-water and surface areas. Temperatures of occupied waters vary from near freezing in winter to 90 F (32 C) in summer (Gorman, pers. comm.). Oxygen levels are generally near saturation (Gorman, pers. comm.). The water may range from clear to murky (from plankton blooms or suspended fine clay particles when the water is very warm) (Gorman, pers. comm.). Occupied streams do not have a strong continuous flow; the flow is usually less than 5 cubic feet per second (Minckley and Cross 1959). Juveniles remain in the shallow margins of pools in mixed-species groups during their first summer. Separation barriers include dams lacking a suitable fishway, high waterfalls, and upland habitat. Forms schools in single-species groups or with stonerollers (CAMPOSTOMA ANOMALUM) (Kerns, unpubl.) (NatureServe, 2015). The Topeka shiner is characteristic of small, low order (headwater), prairie streams with high water quality and cool temperatures. These streams generally exhibit perennial flow, however, some approach intermittency during summer. They are pelagic (living in open water) in nature, occurring in mid-water and surface areas, and are primarily considered a schooling fish (USFWS, 1997).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available

Population Information and Trends

Population Trends:

Declining (USFWS, 2021a)

Species Trends:

> 30% decline (NatureServe, 2015)

Resiliency:

Resiliency: The ability of the species to withstand stochastic events (arising from random factors) Resiliency can often be measured using population metrics such as population growth rates or population size; healthy populations are more resilient and better able to withstand stochastic disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities. While numbers of adult and juvenile Topeka shiners found in surveys (relative abundance), or numbers of collections yielding the species (presence/absence) can provide insight, data is currently lacking to define population metrics. Gathering the necessary information across the species' range would be complicated by the relatively high variability in annual, seasonal, locational, and event-driven factors that impact various life stages and ecological levels of this short-lived species; efforts to obtain necessary population metrics to accurately determine resiliency have not yet been undertaken. As a proxy to population demographics, we look to the habitat characteristics that support Topeka shiner populations to describe the needs of the species in terms of resiliency. Habitats that retain their pre-European settlement characteristics are most apt to support healthy Topeka shiner populations. These are generally unobstructed streams surrounded by intact grasslands and/or adequate riparian buffers to protect instream habitat quality, supporting the natural prairie stream hydrology and morphology. The streams are typically sinuous with gravel-lined pools, and groundwater input (affording critical refugia), adequate food sources, optimal temperatures for reproduction/growth/survival, good water chemistry (e.g. low contaminant levels, adequate dissolved oxygen), low flow rates, and connectivity among and within stream channels. Natural disturbances affecting these streams (floods and droughts) may impact the species negatively at a local scale, but under certain conditions have the potential to improve the species' distribution. Topeka shiner resiliency requires numerous streams with instream habitats that support healthy subpopulations and populations, which combine to form numerous population complexes. Since population complexes are groups of populations that exist in proximity within a larger watershed, numerous functional complexes (i.e. complexes with adequate refugia and connectivity) afford resiliency at a species level. When one population is negatively impacted or extirpated, other populations nearby have the potential to bolster the impacted population or recolonize. The Topeka shiner is not a migratory fish; its relatively sedentary nature and tendency to occupy headwaters (as well as current anthropomorphic influences) mean that neither full occupation within a population complex nor recolonizations are guaranteed. Disturbances in some cases that are detrimental to individuals can be beneficial to the species at the population and population complex scale when environmental events (particularly flooding) facilitate movements. When numerous populations exist in proximity to form a complex, and suitable habitat/refugia exist without barriers to movement, the potential for long-term persistence (resiliency) of the species is improved. Based solely on continued persistence, some populations and population complexes of the Topeka shiner appear to have been more resilient over time than others. Numerous factors affect the species' resilience and are described elsewhere herein, but to improve the Topeka shiner's long-term viability as a species, persistence must at least be maintained in areas where they are currently doing relatively well and improved in areas where they have been reduced in number to the point of tenuous persistence or have been extirpated (USFWS, 2018).

Representation:

Representation: The ability of the species to adapt to changing environmental conditions. Representation can be measured through the breadth of genetic diversity within and among populations, and the ecological diversity (also called environmental variation or diversity) across the species' range. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human-caused) in its environment. Loss of representation can lead to lower viability because of diminished adaptive capacity. a) Genetic Representation Being a relatively sedentary, small, and non-migratory fish, the Topeka shiner is limited (barring outside influences) in its movements to within the connected suitable habitats within the branched waterway system of its respective watersheds of occurrence. At a small scale (subpopulations and populations) movements and mixing of individuals within HUC12 and HUC10 streams may often occur under conducive conditions; yet genetic differentiation among individuals at these levels is known to exist, suggesting long-term isolation sometimes occurs (Blank et al. 2011). At a larger scale (within population complexes), the potential for movement and mixing between HUC10 streams is reduced. Distribution maps (Figure 1 above, Appendix B) indicate such movements have occurred in the past (i.e. numerous adjacent HUC10s are occupied within their larger watersheds), but genetic differentiation is known at the HUC10 level as well, demonstrating the generally isolative tendencies of this species (Michels 2000). Without additional information, however, we cannot rule out the potential for movements between HUC10s within population complexes in many instances. Further, the existence of a number of occupied HUC10s within these population complexes is likely important to the long-term persistence of the species on the landscape. When considering interactions scaled up to the level of population complexes across the range of the Topeka shiner, however, it becomes clear that complexes are separated by insurmountable distances (e.g. 300+ miles), barriers (e.g. impassible dams) and/or unsuitable habitats (e.g. Missouri River) that are highly unlikely to be overcome by the Topeka shiner given its known life history. Given the physical isolation of most population complexes and the genetic differentiation demonstrated at a fine scale within them, it is likely that genetic distinctions between population complexes will become increasingly differentiated over time. The degree to which Topeka shiner representation, and therefore adaptive capacity, has been reduced via past losses of populations and population complexes potentially harboring unique genetic characteristics is unknown. Given the estimated 80% reduction in formerly known occupied areas, the majority of which has occurred in southern states within the range, the reduction could be significant. The traits in the species that may have been affected by those losses – as well as traits affected by current genetic diversity – are also unknown. High genetic diversity would provide this species with increased opportunity to adapt to environmental challenges of the future, including changes in climate. To preclude further decline in Topeka shiner representation and conserve the highest level of adaptive capacity, existing genetic variability in the species across its range would have to be preserved. b) Ecological Representation The range of the Topeka shiner includes six states, but is generally confined to the Great Plains Level I Ecoregion (U.S. EPA 2017). Within this area, additional ecological subdivisions exist (Ecoregion Levels II, III and IV (U.S. EPA 2017)) that cross borders between northern and southern states. In our endeavor to identify representative units, an analysis of Level III and IV Ecoregions overlaid with existing occupied Topeka shiner watersheds was conducted, but did not reveal a clear correlation between Ecoregion type and ecological representation of the species (Table 5). Various Ecoregions overlapped portions of various known occupied watersheds, and with exception of the recent glaciation in northern areas discussed earlier, no known adaptations in the Topeka shiner could be linked to the different ecological conditions that may occur within the Ecoregions (USFWS, 2018).

Redundancy:

Redundancy: The ability of a species to withstand catastrophic events: rare destructive natural events or episodes involving many populations and occurring suddenly/unexpectedly. Redundancy is about spreading the risk. This can be measured through the duplication and distribution of resilient populations across the range of the species. At a species level, the population complex becomes an important unit for measuring redundancy. The greater the number of resilient Topeka shiner population complexes distributed across the species' range, the better it is able to withstand catastrophic events. Before European settlement, the Topeka shiner occupied a relatively large range across six states in the Great Plains. Redundancy for this species has been in decline since the Topeka shiner was first described; subpopulations, populations, and population complexes have been shrinking or have been completely extirpated over time, particularly in the southern parts of the range. Northern areas of South Dakota and Minnesota are estimated by the Service to contain 70% of extant populations, but only 20% of the species' former range (USFWS 2009). This disparity, and the decline of redundancy in the southern states, has decreased the ability of the species to withstand catastrophic events. Drought in particular can be widespread across the Great Plains, potentially negatively affecting large parts of the Topeka shiner's range. Despite the drought tolerance exhibited by the species (Topeka shiners have been documented to expand and become more abundant under conditions created by drought (Minckley and Cross 1959, Barber 1986)), when drought becomes severe (e.g. no refugia) or if degraded habitat conditions or other factors exacerbate stressors on the species, loss of Topeka shiner populations will result. The existence of many, broadly distributed populations and population complexes across the range serve to buffer the risk of catastrophic effects to the species. To persist long-term on the landscape and decrease future risk of declines/extirpations, the species needs numerous healthy (resilient) populations that compose resilient population complexes that are distributed throughout the Topeka shiner's six-state range. Relatively high redundancy among northern populations has been maintained over time – particularly in South Dakota and Minnesota Topeka shiners continue to occupy the majority of their previously known range. In contrast, redundancy among more southern populations has declined significantly and this trend is ongoing. In order for the Topeka shiner to be viable longterm, subpopulation/population and perhaps population complex redundancy would need to remain stable or increase in northern populations and increase in southern areas (USFWS, 2018).

Number of Populations:

87 (USFWS, 2021a)

Population Size:

Unknown, probably >10,000 (NatureServe, 2015)

Population Narrative:

At the time of listing in 1998, the Topeka shiner's known occupied range was thought to have declined by approximately 80 percent, with about 50 percent of that loss occurring rapidly within the previous 25 years. This population decline was due primarily to anthropogenic factors, particularly agricultural activities, which negatively affected the quality of prairie stream habitats since Europeans settled the prairie (Service 2018, p. 7). At the time of listing we knew of approximately 57 occupied stream sites (63 FR 69008). However, surveys for the species conducted after 1998 revealed a significantly broader distribution of the Topeka shiner than was known at the time of listing, primarily within South Dakota and Minnesota. These surveys indicated that the species' range had not significantly declined from prior known boundaries in those states, but that population losses continued in the southern portions of the species' range. The States of South Dakota and Minnesota are now estimated to support 70 percent of the Topeka shiner's range, but in 1998, these areas were previously thought to contain only 20 percent of the estimated range (Service 2018, p. 7). (USFWS, 2021a)

Threats and Stressors

Stressor: Hydrologic changes (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: The conversion of prairie to cropland has altered the hydrology of streams throughout much of the species' historic and present range. Some areas where the species has declined coincide with reduced aquifers and drainage patterns affecting the quantity of water (Cross 1970). Decreased flows of springs, seeps, and other groundwater sources continue to threaten some existing populations, especially highly isolated populations (Cross 1970; Cross and Moss 1987). New and continued groundwater withdrawal can cause or exacerbate stream hydrologic changes, including the seasonality of flows. Ethanol production is very water intensive and generally requires 3 to 4 gallons of water per gallon of ethanol produced (Aden 2007). Cropland irrigation and water use also have the potential to impact stream hydrology for the Topeka shiner across portions of its range (Cross and Moss 1987; Berg et al. 2004). Groundwater withdrawals for these purposes have likely been a substantial issue in irrigation-dependent areas like Kansas and Nebraska, but is also relevant across the remainder of the species' range. The severity of this threat is likely to increase over time as increasing land is cultivated for cropland use (Stubbs 2007; U.S. Department of Agriculture 2007; U.S. Department of Agriculture 2008). In the southern portion of the species' range, stream hydrology has been substantially altered. This change appears to have negatively impacted the Topeka shiner across this portion of its range. These alterations include mainstem and tributary impoundments, groundwater pumping, grassland conversion to row cropping, landcover changes from grassland to woody vegetation, and, in Iowa, tiling and channelization (USFWS, 2009). Southern states within the species' range (Nebraska, Kansas, and Missouri) with older glacial records and relatively well drained hydrologic systems have experienced greater Topeka shiner population losses (Service 2018, p. 1). Additionally, the northern populations may have a greater prevalence of vegetated stream buffers (Service 2018, p. 90) that provide protections for instream habitat. In short, the most pervasive stressors causing the species to decline in some areas can be lumped under the umbrella of altered hydrology (hydrologic changes) (Service 2018, p. 91). The majority of watersheds that support the Topeka shiner were converted to croplands before 2008, such as in Iowa where the watersheds were almost entirely completely cropland prior to 2008. However, cropland conversions have occurred more recently (after 2008) in eastern South Dakota, the potential core or stronghold of the Topeka shiner range. Recent and substantial cropland conversions in the northern populations are concerning, given that these populations are some of the most resilient across the species' range (Service 2020, entire). The expansion of tiling throughout the Topeka shiner's range could also affect the species by reducing stream habitat

and increasing water contamination. We attempted to map the spatial extent of tiling, however, the data does not exist that would allow us to assess this risk. However, the cropland analysis shows the significant extent of current cropland throughout the Topeka shiner's range and highlights areas that could be converted to cropland in the future. As a result, it is reasonable to conclude that most areas throughout the Topeka shiner's range may be subject to impacts from the expansion of cropland tile drainage, except for the Flint Hills in Kansas. (USFWS, 2021a)

Stressor: Agricultural impacts on water quality (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Sedimentation from agricultural runoff and over-grazing of riparian areas continues to impact spawning habitat and water quality across the species' range (Cross and Moss 1987). These water quality parameters include nutrient enrichment and turbidity, which decrease dissolved oxygen and increase water temperatures. Watersheds with high levels of cultivation, and subsequent siltation and domestic pollution, are unsuitable for the species (Cross and Moss 1987). These streams often cease to flow and become warm and muddy during the summer months. Rowcrop agriculture and conversion to rowcrop agriculture is considered a moderate to high level threat across the southern portions of the range and a moderate level threat across the northern portions of the range. Agricultural drainage tiling (discussed above) can also impact water quality by allowing runoff events to enter directly into nearby streams and lakes. This practice causes increased peak flows of shorter duration. Agricultural drainage tiling can also decrease stream temperatures. This impact changes the fish community makeup frequently precluding warm water fish like the Topeka shiner. Finally, these flows often carry high levels of nitrates, sediment and pesticides. Confined animal feeding operations occur throughout the Topeka shiner range. Manure lagoon failures and accidents occasionally occur, often resulting in catastrophic impacts to stream habitat and organisms. Small scale (less than 200 cattle) winter feeding lots are generally not regulated and can introduce large amounts of sediment and nutrients to streams during precipitation events (Bayless and McManus 2001). These spills can result in isolated fish kill events in some stream segments (USFWS, 2009).

Stressor: Road and bridge construction (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Highway and bridge construction and repair actions continue to impact habitat downstream despite active consultation with the action agencies. These activities inherently disturb in-channel and riparian areas, which are then subject to weather-related events during and immediately following construction. In many cases, heavy rains with associated runoff will release large volumes of sediment to the channel despite use of best management practices for erosion control. The placement of culverts associated with road and bridge work also can impact Topeka shiner. Throughout much of the species' range there are culverts that inhibit or prohibit fish passage due to extreme stream elevation changes and/or high water velocities (Bouska 2008) (USFWS, 2009).

Stressor: Urbanization (USFWS, 2009)
Exposure:
Response:

Consequence:
Narrative: Urbanization continues to impact the species and its habitat. Impacts include nutrient enrichment, hydrologic changes and the related need for future channelization and bank stabilization, and the escapement of predacious fishes from many newly constructed small impoundments in the watershed (Keller 1985). In 2005, repeated heavy rains in the Wildcat Creek watershed near Manhattan, Kansas led to large volumes of sediment being eroded from a large construction site. This caused habitat degradation downstream (Tabor pers. comm. 2005). Rural residential development also is occurring in portions of the Mission and Mill Creek watersheds west of Topeka, Kansas. In South Dakota, development in and near Sioux Falls has greatly increased within the period of the 1990s to present, and growth is expected to continue (USFWS, 2009).

Stressor: Impoundments (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: In the 30 years prior to listing, large numbers of tributary impoundments were constructed in portions of the species' Kansas, Missouri, and Nebraska range. These impoundments are strongly suspected in the extirpation of the species from many streams and watersheds (Pflieger in litt. 1992; Layher 1993). During times of diminished flows or drought, Topeka shiner populations upstream from impoundments attempt to use these water bodies as refuges. These populations are then subject to predation by piscivorous fishes in these ponds and lakes (Layher 1993; Mammoloiti 2002). Tributary dams also prevent upstream migration of fishes following drought, prohibiting recolonization of upstream reaches. Populations remaining downstream of impoundments face additional threats from altered flow regimes and the degradation of habitat related to changed hydrologic regimes (USFWS, 2009).

Stressor: Dredging (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: In Kansas and Missouri, instream gravel mining/dredging can release large volumes of sediment into downstream habitat impacting water quality and spawning substrate (Cross et al. 1982). Dredging/mining alters stream morphology, by reducing pool and riffle complexes, and encourages upstream head-cutting which releases additional sediment to the stream as the streambed is eroded and streambanks collapse. In Iowa and Minnesota, periodic dredging of accumulated sediment from drainage ditches upstream can similarly release large sediment loads to downstream habitat, impacting water quality and spawning substrate (McPeek pers. comm. 2006) (USFWS, 2009).

Stressor: Asian tapeworm (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Asian tapeworm (Bothriocephalus acheilognathi) has been reported to negatively affect Topeka shiner growth and survival (Koehle 2006). It was believed that this population was likely exposed to the parasite as a result of the ponds previously holding grass carp (Ctenopharyngodon idella) (Campbell pers. comm. 2006). At this time, the level of threat to

Topeka shiner from the Asian tapeworm is not known (USFWS, 2009).

Stressor: Predation (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Predation of Topeka shiners by introduced piscivores is now believed to provide a greater threat to the species than previously known. The green sunfish is the most common predator typically occurring with Topeka shiner across its range, often being found in the same pools (Tabor pers. comm. 2009). The spotted bass (Micropterus punctulatus) and largemouth bass (M. salmoides) also are naturally occurring predators of the Topeka shiner in the southern portions of its range. The construction of tributary impoundments on streams with Topeka shiners, and the subsequent introduction of piscivorous fishes not typically found in headwater habitats, such as largemouth bass and crappies (Pomoxis spp.) can seriously impact the species (Layher 1993; Winston 2002). Some of the most common fishes typically captured in streams directly upstream and downstream of tributary impoundments in Kansas and Missouri are largemouth bass, bluegill (Lepomis macrochirus), and crappie. These species predate and typically eliminate Topeka shiners and other stream cyprinids (minnow species) (Mammoliti 2002; Kerns pers. comm. 2005). Direct stocking of piscivorous fishes into or near Topeka shiner habitat for sportfishing benefit also can impact the species. It appears that the high plains remnant population of Topeka shiner was eliminated following the introduction of largemouth bass into stream habitat in Wallace County, Kansas (Tabor pers. comm. 2005) (USFWS, 2009).

Stressor: Drought (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: The occurrence of drought in the prairie landscape is a natural phenomenon historically tolerated by the Topeka shiner in unaltered habitat. Drought has an increasing impact on the species as watershed development and land-use changes occur, decreasing the connectivity and increasing the isolation of existing populations. Much of the remaining range of the Topeka shiner in Iowa, Kansas, Missouri, and Nebraska consists of highly fragmented, isolated populations with long distances of altered or unsuitable habitat between them, prohibiting redistribution. Many of these populations do not have the necessary downstream or off-channel refuges available to them to survive long-term drought conditions at this time. Increased periods of protracted drought, potentially resulting from climate change, would exacerbate the impacts of habitat fragmentation and isolation (Deacon 1961; Cross 1967; Mammoliti 2002; Knight and Gido 2005; Karl et al. 2009). Increased drought could also impact presently stable population complexes, forcing these populations to seek refuge downstream into larger streams with more predacious fishes and diminished habitat value (USFWS, 2009).

Stressor: Climate change (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: The average temperature in the Great Plains already has increased roughly 1.5°F relative to a 1960s and 1970s baseline (Karl et al. 2009). Localized projections suggest that much of the range of the Topeka shiner may experience temperature increases of 4°F to 6°F under the

lower emissions scenario or increases of 7°F to 11°F under the higher emissions scenario before the end of the century (Karl et al. 2009). Precipitation has also been impacted by climate change. In the last 50 years, total precipitation has increased up to 20 percent across northern portions of the range, while changes in the southern areas have ranged from declines of up to 5 percent to increases up to 20 percent (Karl et al. 2009). Heavy precipitation events have increased between 15 and 31 percent over the last 50 years (Karl et al. 2009). Impacts in summer are of particular concern. Increased air temperatures will lead to higher water temperatures, especially during low-flow periods. Reduced summer precipitation and increased evaporation is likely to reduce flows. Such conditions cause increased stress to fish. The timing and amount of precipitation will also impact groundwater recharge rates. Finally, substantially hotter summers would likely increase agricultural demand for surface-water and ground-water resources. Thus, the available information indicates climate change is a substantial long-term risk factor which could meaningfully impact water quantity and the suitability of stream habitat (USFWS, 2009).

Stressor: Selenium (USFWS, 2021a)
Exposure:
Response:
Consequence:
Narrative: Most of the watersheds with Topeka shiner populations, except for those in Kansas, occur in areas with naturally occurring selenium geology (Service 2020, entire). Streams in South Dakota with extensive selenium geology and tile drainage have shown increased selenium levels. The potential effects of selenium on the Topeka shiner are currently not known, but the literature on other cyprinid fish species indicate it could negatively affect individual fitness and reproductive health. The past, current and future use of tile drainage in agriculture fields could exacerbate the harmful effects of selenium on the Topeka shiner. Toxicity research is needed to fully assess how selenium may affect the species. (USFWS, 2021a)

Recovery

Reclassification Criteria:
Not available - this species does not have a recovery plan.

Delisting Criteria:
Criterion 1. Representation: The purpose of this criterion is to maintain the species across a broad portion of its current ecological settings to preserve future adaptive capacity and potential. Maintain nine Population Complexes with documented persistence (Population Complexes A through I in Figure 1; however, newly discovered/created Population Complex(s) could count towards the nine if they meet the definition of a Population Complex and have documented persistence) (USFWS, 2021).

Criterion 2. Redundancy: The purpose of this criterion is to maintain, increase, and expand populations in currently known occupied habitats to ensure species self-sustainability by mitigating catastrophic events. Each of the nine Population Complexes counting towards Criterion 1 must have at least 50–70 percent1 of its next lower watersheds/sub-watersheds (either Hydrologic Unit Code (HUC) 10s or 12s depending on the Population Complex; USFWS 2018), with a history of or potential for Topeka shiner occupancy within that complex, confirmed as persistent. (USFWS, 2021).

Criterion 3. Resiliency: The purpose of this criterion is to increase the ability of populations in currently known occupied habitats to resist impacts of stochastic events and persist long-term. Each of the watersheds/sub-watersheds counting towards the 50–70 percent in Criterion 2 must have at least two separate2 lower level occupied streams or separate sites within the continuum of those watersheds confirmed as persistent. (USFWS, 2021).

Criterion 4. Conservation Plans: The purpose of this criterion is to ensure future maintenance of Topeka shiner populations. (USFWS, 2021).

Recovery Actions:

- Not available - this species does not have a recovery plan.
- Prepare a downlisting package when sufficient resources (funding and personnel) are available, including a 4(d) rule to limit the regulatory impacts of the listing in portions of the Topeka shiner range where the species is doing well (USFWS, 2009).
- Develop a draft and final recovery plan for the Topeka shiner. The recovery plan should include objective, measurable delisting criteria. The recovery plan will not include downlisting criteria as the species already warrants threatened status. The recovery plan will consider whether it is appropriate to identify multiple DPSs with independent delisting criteria (see Section 2.1.3 above). The recovery plan will also consider whether we should identify recovery units or management units related to drainages and species' genetics. Recovery criteria should address all threats meaningfully impacting the species. The recovery plans also should estimate the time required and the cost to carry out those measures needed to achieve the goal for recovery and delisting (USFWS, 2009).
- Develop and implement a standardized and, to the extent practical, quantitative method for prioritizing recovery actions and tracking recovery implementation so that progress toward eliminating threats can be regularly summarized (USFWS, 2009).
- Improve and standardize the monitoring process for Topeka shiner populations' distribution, abundance, and trends (USFWS, 2009).
- Enlist and support the full engagement of Federal, State, local, tribal, and private partners in Topeka shiner recovery (USFWS, 2009).
- Recovery Strategy The recovery strategy describes the path needed to achieve the recovery vision. The primary strategy to recover Topeka shiner is to: 1. Engage all conservation partners to collaborate, coordinate and implement recovery actions. Recovery will require the cooperation and dedication of natural resource managers, conservationists, ranchers, farmers, agencies, and those with expertise needed to design and evaluate the effects of recovery actions on the species. This will require clear communication about the species' needs, where it occurs, its conservation challenges, and the potential implications and locations of recovery actions. It will be critical to ensure that recovery goals are met in a manner that is in concert with the missions, objectives, and aspirations of our conservation partners. 2. Conserve adaptive capacity and ecological diversity of the species. The Population Complexes are the surrogates for the ecologic, geographic, genetic diversity, and adaptive capacity across the range. The recovery strategy includes the restoration of gene flow between populations, to the extent possible, by designing and implementing actions that emphasize conservation of genetic diversity within the Population Complexes and isolated populations when the opportunity is presented. 3. Fully quantify and/or qualify population demographics and status within each of nine Population Complexes. We consider A-I in Figure 2 to be Topeka shiner Population Complexes for the purposes of this

recovery plan. Other groups of Topeka shiners (J-M) likely were part of a larger complex at one time but are currently considered Isolated Populations. 4. Improve population size and viability within each of nine Population Complexes. The Population Complexes are critical for the long-term persistence of the species and provide unique opportunities for restoration of landscape-level ecological processes (i.e., floodplain connectivity) that formerly benefited the species throughout its large historical range. 5. Reduce threats having adverse effects on the species within the nine Population Complexes (e.g., habitat degradation and fragmentation, altered hydrology, contaminants, channel stabilization, water Recovery Plan for Topeka Shiner diversion, impoundments, agricultural practices, predator removal, and potential effects related to climate change). 6. Employ a rigorous adaptive management and monitoring framework for implementing recovery that will allow for better and sustainable management for suitable habitat conditions, protection against wide-ranging and simultaneous population declines due to environmental stochasticity and catastrophes, and responsiveness to adverse effects of climate change. 7. Emphasize land and water stewardship practices that offer the best conservation benefit for the species within each of the nine Population Complexes. 8. Maximize conservation opportunities, such as reintroduction and habitat restoration, in isolated populations to contribute to the overall recovery of the species across the range. 9. Use captive propagation, in concert with conservation measures, to bolster populations/population complexes as well as isolated populations to prevent local extirpations where recruitment failure is occurring. Captive reared Topeka shiners may also be reintroduced within historically occupied watersheds or those with current and/or recent declines or extirpations, given quality habitat exists. Critical to these endeavors is understanding the threats facing the species and instituting mechanisms to ameliorate the sources of such threats. (USFWS, 2021).

- 1. Habitat Protection, Management, and Restoration - Implement actions to protect, maintain and restore habitat quality and quantity sufficient to achieve and sustain recovery criteria. These actions can be achieved by collaborative planning and prioritizing actions within priority areas that include contingencies for threats and catastrophes. Habitat protection can be maintained through a combination of various mechanisms such as acquisitions, long-term easements, short-term conservation programs, cooperative agreements, and incentives provided through conservation agencies and sustainable organizations. Habitat restoration will provide buffers from threats and act as potential dispersal corridors. Recovery actions will be detailed in the RIS given the specific geographic location in the species range and input from respective state partners. Examples of recovery actions include: 1. Oxbow restoration, riparian and instream restoration, fish passage, and floodplain connectivity at various spatial scales. 2. Creation of riparian buffers to improve water quality through filtration of runoff, improve channel stability, reduce streambank erosion, and enhance habitat diversity. 3. Cattle exclusion from streams and oxbows to improve water quality, improve bank stability, and protect riparian areas. 4. Mitigation of the effects of confined animal feeding operations, smaller feedlots, and overall nutrient reduction. 5. Improve groundwater management and conservation, where applicable, by working with groundwater management districts to reduce rates of groundwater depletion and impacts to natural stream flows. 6. Limit the effects of agricultural land uses not conducive to high quality Topeka shiner habitat, for example production and overgrazing on highly erodible lands, tilling, pond development, overgrazing, eutrophication, and tiling. 7. Removal of man-made structures such as perched culverts or dams which act as barriers to movement of aquatic organisms and materials, significantly alter natural hydrology, or create aquatic habitat that promotes larger predator species. Recovery Plan for Topeka

Shiner 8. Installations of stream crossings which allow for fish passage, provide grade control for the stream channel, and facilitate responsible land management. 9. Mitigating or eliminating instream gravel mining where applicable. 10. Easements, fee title, mitigation banks, and land acquisition. (USFWS, 2021).

- 2. Population Management, Augmentation, Translocations, and Reintroductions - In coordination with partners, develop and implement strategies for population management that is successful to meet the recovery criteria. This may include conservation propagation methods such as augmentation, enhancement, translocation, and reintroductions. After a thorough science assessment, determine locations where augmentation, translocation and reintroduction may be appropriate and coordinate with partners for proper execution. This includes surveys, coordination, and monitoring. 1. Augment or reintroduce populations in states such as Missouri, Kansas, and Nebraska that have small, isolated populations and ensure that suitable habitat conditions exist. 2. Inventory unoccupied, suitable prairie streams within the species' range for species status updates and potential reintroductions or other recovery efforts. 3. Develop genetic management plans for reintroductions and augmentations. 4. Explore opportunities to conserve genetically unique populations, especially with small isolated complexes or populations, by using fisheries management approaches. 5. Develop and implement conservation tools such as Section 10(j) of the Endangered Species Act, Safe Harbor Agreements and the States' Section 6 (i.e., management and cooperative agreements and allocation of funds) (USFWS, 2021).
- 3. Monitoring - It is also critical that Federal, State, and non-government partners track the effects (positive and negative) of their actions in the field through population and habitat monitoring. This entails developing monitoring protocols, increased monitoring at the watershed scale of both extant and new sites, conducting appropriate surveys at potential new sites, and improved data sharing among partners. 1. Partners in each state will establish a standardized survey and monitoring protocol to assess and track progress. The sampling design should at a minimum provide estimates of occupancy and detection probabilities with associated error. The USFWS will work with state partners to establish a standardized survey and monitoring protocol. 2. When significant stochastic events occur, partners will assess the impact on habitat conditions and populations and determine how the change affects recovery of a population (i.e., implementation of recovery actions). Implement adaptive management when necessary. 3. Annually report: USFWS Field Offices within the species' range report to each other. Recovery Plan for Topeka Shiner a. Call between USFWS Ecological Services field offices to share new data and information, adaptive management strategies, partner's issues and concerns. b. Bi-Region Species Lead (Kansas) report out to Recovery Team (USFWS, 2021).
- 4. Research - Conduct critical research projects, using a rigorous adaptive management framework, that prioritize and optimize recovery actions. Needs include: 1. Fish passage obstruction inventory and prioritization schema for removal or retrofitting. 2. Additional sampling to explore genetic diversity for the purpose of reintroductions and augmentations. 3. Sample for eDNA for the purpose of population and distribution monitoring. 4. Determine Topeka shiner movement rates and extent to inform population management and guide restoration/mitigation efforts. 5. Describe impacts of climate change on hydrologic characteristics of streams across the range of Topeka shiners and consider these consequences for achieving recovery goals. 6. Describe impacts of agriculture-related changes to hydrology and water quality (e.g., tile draining, chemical runoff) in Topeka shiners streams, species community, habitat response, and options for mitigation. 7. Research the effects of predatory fish on Topeka shiners relative to reproduction,

recruitment, habitat use, movement, foraging, competition, and environmental conditions such as drought. 8. Investigate historical predator distributions and associated diversity at large and small spatial scales and to assess cumulative effects of predator interactions with the Topeka shiner within watersheds. 9. Investigate the effects of drainage development and anthropogenic hydrological alterations on the suitability of in-stream and off-channel Topeka shiner habitat. (USFWS, 2021).

- 5. Collaboration - The collaboration of Federal, State and non-government partners is critical in meeting the recovery criteria. 1. USFWS field offices engage and share information with their state partners on a regular basis and work together in the field on surveys, recovery actions, and monitoring of those recovery actions. 2. Work with Federal partners (i.e., Natural Resources Conservation Service and Wildlife Services) to develop conservation conditions and protections for Topeka shiners in programmatic agreements. 3. Integrate existing state and non-governmental organization (NGO) recovery plans and programs to assist with recovery objectives. Recovery Plan for Topeka Shiner 4. USFWS field offices agree upon recovery permit criteria that will be used to assess the qualifications of applicants actively seeking a recovery permit. 5. Involve specific NGO conservation groups that can efficiently and effectively contribute to recovery actions. This could include funding, labor, materials, technical and legal assistance, public relations, or educational contributions. NGOs may be particularly beneficial when working with private lands. 6. Engage the Partners for Fish and Wildlife program regarding projects on private lands that could benefit landowners and at the same time implement recovery actions (USFWS, 2021).
- 6. Education and Outreach - Develop and foster partnerships to support the conservation of the Topeka shiner while seeking to understand stakeholders' interests. Work with partners to improve awareness of the Topeka shiner and its habitat and provide technical assistance and incentives to private landowners, land managers, and other parties to conserve the species and its aquatic habitat while allowing for continued operation of appropriate activities. 1. Promote management practices and programs (e.g., Conservation Reserve Program, Environmental Quality Incentive Program) that improve both stream health and land management, plus sustain profitability of agricultural lands and ranching operations. 2. Increase and improve collaboration with existing and future watershed projects and initiatives while incorporating continued operations (e.g., agricultural water use, flood attenuation). 3. Inform private landowners and associations of opportunities available regarding safe harbor, section 10(j), and other agreements. 4. Inform and educate the public on landscape impacts and stressors that influence aquatic species and their associated habitats. (USFWS, 2021)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Work with partner agencies and organizations to implement the Topeka Shiner Recovery Plan (Service 2021, entire). • Coordinate with States to complete Recovery Implementation Strategies (RIS) that provide geographically appropriate recovery actions to effectively meet the delisting criteria identified in the recovery plan. • Forecast/model land conversion from prairie to row crop agriculture and resulting increase in drainage tiling and potential increases in naturally occurring selenium levels in streams. It is currently not known how sensitive individual Topeka shiners are to elevated selenium levels; a future toxicity study would provide information about the risk from increasing selenium levels in Topeka shiner habitat. (USFWS, 2021a)
- At present, ongoing conservation actions specifically for the Topeka shiner include construction of off-channel habitats in Iowa and Minnesota, and captive rearing of the Topeka shiner in Kansas and

Missouri, with reintroductions occurring in Missouri. While these are important conservation actions, which have been successful to date, they are limited to a few areas and are not occurring across the species' range. Some non-targeted actions, such as Minnesota's Buffer Law (that requires perennial vegetation buffers with an average width of 50 feet (15 meters) and a minimum width of 30 feet (9 meters) along rivers and streams), likely will afford benefits to the species' habitat, but such laws do not exist in the other 5 states of the Topeka shiner's range. (USFWS, 2021a)

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SPECIES ACCOUNT: *Noturus baileyi* (Smoky madtom)

Species Taxonomic and Listing Information

Listing Status: Experimental Population, Non-Essential; 10/26/1984, 08/12/2002; Southeast Region (R4) (USFWS, 2016)

Physical Description

The smoky madtom is a small [largest 61.5 mm (2.5 inches) SL, 73.0 mm (2.9 inches) TL] light brown colored catfish (see Taylor, 1969). Its head is relatively large and rounded above, the eyes are small, and the mouth is subterminal with very short barbels. The pectoral spines are only slightly curved and have fine anterior serral and moderately large posterior serral. The dorsal spine is short, about 2/5 length of longest dorsal ray. The dorsal area is marked with four small saddles located, on top of the head, beneath the front of the dorsal fin, between the dorsal fin and the adipose fin, and beneath the adipose fin. [USFWS 1985]

Taxonomy

This species is a small member of the catfish family [USFWS 1985].

Historical Range

The smoky madtom was believed to have become extinct in 1957 when it was extirpated from Abrams Creek, Great Smoky Mountains National Park, Blount County, Tennessee. It was rediscovered in Citico Creek in 1980 (Bauer et al. 1983). The results of an extensive survey (Dinkins, 1982) indicate that the species when listed was apparently restricted to approximately 6.5 miles (10.5 km) of Citico Creek primarily within the Cherokee National Forest, Monroe County, Tennessee. [USFWS 1985]

Current Range

In 1985, the smoky madtom was only found in Citico Creek. The species has since been reintroduced into Abrams Creek and has maintained itself in the absence of stockings since 2004. The Citico Creek population is considered stable to increasing. The smoky madtom has also recently been introduced into the Tellico River, and there is now evidence of natural reproduction and successful recruitment of new year classes [USFWS 2012].

Distinct Population Segments Defined

Yes [inferred by USFWS 1985]

Critical Habitat Designated

Yes; 10/26/1984.

Legal Description

On October 26, 1984, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Smoky madtom (Noturus baileyi) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes Citico Creek in Monroe County, Tennessee (49 FR 43065-43069).

Critical Habitat Designation

The critical habitat designation for the Smoky madtom is Citico Creek in Monroe County, TN (49 FR 43065-43069). Citico Creek from the Cherokee National Forest boundary at upper Citico Bridge on Mountain Settlement Road (approximately creek mile 4.3) upstream to the confluence of Citico Creek with Barkcamp Branch (approximately creek mile 10.8).

Primary Constituent Elements/Physical or Biological Features

Constituent elements of the critical habitat include the present good water quality in Citico Creek and run/pool areas with relatively silt-free pea-size gravel substrate containing scattered large flat rocks for breeding habitat. The species utilizes palm-size slab rocks for cover and relatively silt-free riffle areas during other times of the year. The area designated as critical habitat provides the smoky madtom with all of the necessary constituent elements for completion of its life cycle.

Special Management Considerations or Protections

In addition to the present high water quality in Citico Creek, the smoky madtom requires run/pool areas with pea-size gravel substrate containing scattered large flat rocks for nesting cover. The species utilizes palm-sized slab rocks for cover and relatively siltfree riffle areas during other times of the year. The area designated as critical habitat provides the smoky madtom with all of the necessary constituent elements for completion of its life cycle. If the quality of this creek section can be maititained near its present level and no catastrophic event occurs, the species will likely continue to survive in Citico Creek.

Life History

Feeding Narrative

Juvenile: Noturus baileyi is a generalist invertivore that feeds primarily on aquatic insect larvae [NatureServe 2015; USFWS 1984]. The species is nocturnal. An examination of its stomach contents found gravel, suggesting the species feeds by picking prey items from the substrate [USFWS 1985].

Adult: Noturus baileyi is a generalist invertivore that feeds primarily on aquatic insect larvae [NatureServe 2015; USFWS 1984]. The species is nocturnal. An examination of its stomach contents found gravel, suggesting the species feeds by picking prey items from the substrate [USFWS 1985].

Reproduction Narrative

Juvenile: Smoky madtom reproduces sexually after one year, during the summer. The typical lifespan of an individual is 2 years. Breeding season as evidenced by nesting occurs May-July. Spawning has been observed through August. Nests have been observed under large slab rocks in pool areas [NatureServe 2015]. The species shows evidence of polyandry [USFWS 2012].

Adult: Smoky madtom reproduces sexually after one year, during the summer. The typical lifespan of an individual is 2 years. Breeding season as evidenced by nesting occurs May-July. Spawning has been observed through August. Nests have been observed under large slab rocks in pool areas [NatureServe 2015]. The species shows evidence of polyandry [USFWS 2012].

Geographic or Habitat Restraints or Barriers

Juvenile: Creek above section of inhabited area is apparently unsuitable for fish, possibly due to high gradient (76.6 ft/mile) [USFWS 1985].

Adult: Creek above section of inhabited area is apparently unsuitable for fish, possibly due to high gradient (76.6 ft/mile) [USFWS 1985].

Habitat Narrative

Juvenile: The smoky madtom is a freshwater fish that inhabits small streams or creeks of small to moderate gradient: as much as 13.2 ft/mile. The species is associated with shallow riffles containing abundant flat palm size slab rocks, shallow pools with pea size gravel and scattered flat rocks, and deep pools with silty/sandy bottoms and large boulders. The Citico Creek above the section of inhabited areas is apparently unsuitable for fish, possibly due to a high surface gradient [USFWS 1985].

Adult: The smoky madtom is a freshwater fish that inhabits small streams or creeks of small to moderate gradient: as much as 13.2 ft/mile. The species is associated with shallow riffles containing abundant flat palm size slab rocks, shallow pools with pea size gravel and scattered flat rocks, and deep pools with silty/sandy bottoms and large boulders. The Citico Creek above the section of inhabited areas is apparently unsuitable for fish, possibly due to a high surface gradient [USFWS 1985].

Dispersal/Migration

Motility/Mobility

Juvenile: Low [inferred from USFWS 2012]

Adult: Low [inferred from USFWS 2012]

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Non-migrant [inferred from USFWS 2012]

Adult: Non-migrant [inferred from USFWS 2012]

Dispersal

Juvenile: Low [inferred from USFWS 2012]

Adult: Low [inferred from USFWS 2012]

Immigration/Emigration

Juvenile: No [inferred from USFWS 2012]

Adult: No [inferred from USFWS 2012]

Dependency on Other Individuals or Species for Dispersal

Juvenile: No [inferred from USFWS 2012]

Adult: No [inferred from USFWS 2012]

Dispersal/Migration Narrative

Juvenile: The species exhibits low motility/mobility, is non-migrant, shows low dispersal, does not immigrate/emigrate, and is not dependent on other individuals at an intraspecific level for dispersal/migration [inferred from USFWS 2012].

Adult: The species exhibits low motility/mobility, is non-migrant, shows low dispersal, does not immigrate/emigrate, and is not dependent on other individuals at an intraspecific level for dispersal/migration [inferred from USFWS 2012].

Population Information and Trends

Population Trends:

Increasing [USFWS 2012]

Resiliency:

Resiliency of a population describes its ability to withstand stochastic events and highly resilient populations are better able to endure major local disturbances (e.g., variations in rainfall, anthropogenic activities, toxic spills). Below we summarize the various factors described above which relate to resilience of each population. These conclusions are based on mainly qualitative information regarding the habitat for each location and any data available for Smoky madtoms in each population. Abrams Creek Detections of Smoky madtoms in Abrams Creek are consistent and natural reproduction is consistent. The population occurs entirely on land managed by the NPS and water quality is good. Generally, the habitat is in good condition but is slightly limited in spatial extent and, therefore, is considered moderate. Overall resilience for this population is High. Citico Creek Detections of Smoky madtoms in Citico Creek are consistent and natural reproduction is consistent. The population occurs entirely on land managed by the USFS and water quality is good. Generally, the habitat is in good condition but is slightly limited in spatial extent and, therefore, is considered moderate. Overall resilience for this population is High. Tellico River Detections of Smoky madtoms in Tellico River have increased over time and are now relatively high. Additionally, natural reproduction is consistent within the river which is surrounded mostly by USFS managed land and water quality is good and improving within occupied habitat. Overall resilience for the Tellico River population is Moderate (USFWS, 2024).

Representation:

Representation refers to the ability of species to adapt to changing environmental conditions and is typically measured as the breadth of genetic or ecological diversity across the species. Moyer and Williams (2012) compared the genetic diversity between Abrams Creek and Citico Creek and found that overall genetic diversity was low, but different between these two populations. There is very little information regarding the historical distribution of Smoky madtoms and it is impossible to know if populations were once more genetically distinct. Therefore, it is unknown if historical representation has been lost or if it remains the same as it was historically. Low representation may limit the species ability to adapt to environmental changes, especially those created by climate change, and a translocation and genetic monitoring plan is being implemented to manage gene flow between populations and preserve what genetic representation remains (Kulp et al. 2015) (USFWS, 2024).

Redundancy:

Redundancy refers to the ability of a species to withstand catastrophic events and is measured by the amount and distribution of resilient populations across the species range. Each Smoky madtom population occurs within one watershed. Catastrophic events that could severely impact or extirpate entire Smoky madtom populations include chemical spills, changes in upstream land use that alters stream characteristics and water quality downstream, new impoundments, and potential effects of climate change such as drought and increases in occurrence of flash flooding events. The likelihood of many of these events are low given the Federal protections afforded to the populations by the NPS and USFS (USFWS, 2024).

Number of Populations:

3 (USFWS, 2024)

Adaptability:

Low [inferred from USFWS 2012]

Population Narrative:

Currently, there are three Smoky Madtom populations in three tributaries of the Little Tennessee River in Tennessee. Smoky Madtom populations in Abrams Creek and Citico Creek are considered viable (Service 2019), and stocking efforts are now focused on the Tellico River population. Monitoring surveys since our last 5-year review indicate that populations remain stable, as demonstrated by continued persistence of Smoky Madtom in Abrams Creek, Citico Creek, and the Tellico River, and observations of natural reproduction and recruitment. (USFWS, 2020). The Smoky madtom is a small madtom species endemic to the Little Tennessee River basin. At listing, only a single population (Citico Creek) was known to exist. Currently, there are three known populations, all occur within tributaries of the Little Tennessee River. Two of the populations, Abrams Creek and Citico Creek, are within the known historical range. The Service designated a nonessential experimental population for the Smoky madtom in Tellico River that has been stocked from captive propagated individuals from the Citico Creek population. The Abrams Creek and Citico Creek populations appear to be stable. The Tellico River population has documented natural reproduction since 2010 and may also be getting close to be fully self-sustaining. Threats to Smoky madtom habitat have been greatly reduced by management actions by the USFS and NPS as most of the range occurs within the CNF and GSMNP. While the species continues to be isolated by impoundments, a genetic plan is being implemented to manage gene flow between populations (USFWS, 2024).

Threats and Stressors

Stressor: Habitat alterations [inferred from USFWS 2012]
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Physical habitat destruction resulting from a variety of human-induced impacts such as siltation, disturbance of riparian corridors, and changes in channel morphology continues to plague the Tennessee River watershed. The most significant of these impacts is siltation caused by excessive releases of sediment from activities such as agriculture, resource extraction (e.g., coal mining, silviculture), road construction, and urban development (Waters 1995). Activities that contribute sediment discharges into a stream system change the erosion or sedimentation pattern, which can lead to the destruction of riparian vegetation, bank collapse, excessive

instream sediment deposition, and increased water turbidity and temperatures. [USFWS 2012]

Stressor: Sedimentation [inferred from USFWS 2012]
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Sediment has been shown to abrade and or suffocate bottom-dwelling organisms by clogging gills; reducing aquatic insect diversity and abundance; impairing fish feeding behavior by altering prey base and reducing visibility of prey; impairing reproduction due to burial of nests; and, ultimately, negatively impacting fish growth, survival, and reproduction (Waters 1995). Wood and Armitage (1997) identified at least five impacts of sedimentation on fish, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency. In addition, Etnier and Jenkins (1980) suggested that madtoms, which are heavily dependent on chemoreception (detection of chemicals) for survival, might be susceptible to human-induced disturbances, such as chemical and sediment inputs, because the olfactory (sense of smell) “noise” they produce could interfere with a madtom’s ability to obtain food and otherwise monitor its environment. The effects of these types of threats will likely increase as human populations grow in the Tennessee River watershed in response to human demands for water, housing, transportation, and places of employment. [USFWS 2012]

Stressor: Pesticides and pollutants [inferred from USFWS 2012]
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Non-point source pollution from land surface runoff can originate from virtually any land use activity (such as coal mining and agricultural activities) and may be correlated with impervious surfaces and storm water runoff from urban areas. Pollutants entering the Tennessee River watershed may include sediments, fertilizers, herbicides, pesticides, animal wastes, pharmaceuticals, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streams such that the habitat and food sources for species like the yellowfin madtom and smoky madtom are negatively impacted. [USFWS 2012]

Stressor: Other anthropogenic activities (development) [inferred from USFWS 2012]
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Common land uses within the Clinch-Powell watershed include urban, industrial, commercial, and residential development; livestock production; agricultural cropping including tobacco and corn; coal mining, reclaimed coal mined lands, and “abandoned” coal mined lands (i.e., lands affected by mining prior to the federal law that were not reclaimed properly); road and railroad networks; and silvicultural practices (US EPA 2002). These land use activities act as sources of stress to the yellowfin madtom by contributing sediment and contaminants into the watershed. In June 2008, a car accident resulted in a gas spill that affected a small portion of Citico Creek in CNF in close proximity to where the yellowfin madtom and smoky madtom are known to exist. The accident occurred approximately 3.2 km (2 mi) upstream from designated

critical habitat for the smoky madtom, and no investigation to officially quantify take was conducted for listed fishes. [USFWS 2012]

Stressor: Small Population Size (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative: The Smoky Madtom is vulnerable to losses in genetic diversity and fitness due to small population sizes. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007). However, the effects of this threat may be reduced through the implementation of the gene exchange and monitoring program (see Section II.C.1.b). (USFWS, 2020)

Stressor: Climate Change (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative: Climate change has the potential to increase vulnerability of Smoky Madtom populations to random catastrophic events or alter habitat suitability within the species' range. By the end of 2100, it is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales, and it is very likely that heat waves and extreme precipitation events will occur with a higher frequency and intensity (IPCC 2014). Projections for future precipitation trends in the southeastern U.S. are less certain than temperature projections; however, it is expected that there will be reduced water availability due to the increased evaporative losses (from increased transpiration from plants and evaporation from soils and water bodies) from rising temperatures alone (Carter et al. 2014). Warmer temperatures and decreased water availability will increase water temperatures, change runoff regimes, and increase the frequency, duration, and intensity of droughts in the southeastern United States (Kunkel et al. 2013). Reduced water availably may be a significant threat to the Smoky Madtom in the long term because an increase in the frequency and duration of dewatering events of suitable habitat may lead to reduced reproduction, nest success, or increase mortality. In 2016, flows and water levels were exceptionally low for most of the late summer survey season with extreme drought conditions extending even into November. Approximately a third to half of Citico Creek was dry in late August, and snorkel sampling became ineffective in habitat most suitable for Smoky Madtom (CFI 2017). (USFWS, 2020)

Stressor: Recreational activities (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: Recreational activities (swimming, wading, horse access to the water; Factor E) within the CNF and the GSMNP can and have resulted in visitors disturbing rocks, impacting nests and dislodging eggs (Shute et al. 2005, Shute per. comm. 2014). The level of disturbance resulting from these recreational activities has the potential to impact multiple nests during single or multiple events throughout the nesting phase, and particularly in areas adjacent to hiking and horseback riding trails and where visitors stop to swim. To mitigate for this impact, both the USFS

and the NPS have implemented educational signage and coordinate with local media to raise public awareness of critical fish habitats. The NPS has also established policy that places a moratorium on disturbing and moving rocks in the GSMNP to further protect spawning aquatic species (USFWS, 2024)

Stressor: Impoundments (USFWS, 2024)
Exposure:
Response:
Consequence:
Narrative: Impoundments continue to be a threat to the three Smoky madtom populations. There are five major impoundments on the Little Tennessee River and one smaller impoundment. These impoundments limit fish species' ability to reestablish populations and prevent gene flow among populations (Shute et al. 2005). The Chilhowee Dam and Tellico Dam are of particular concern because they separate the extant populations. Currently, the small size of Smoky madtom populations leave them vulnerable to environmental and demographic stochastic events (Factor E) (USFWS, 2024).

Recovery

Reclassification Criteria:
When, through protection of the existing Citico Creek population and by introductions of the species back into Abrams Creek, viable populations exist in both creeks (Blount and Monroe Counties, Tennessee) [USFWS 2012];

the U.S. Forest Service and National Park Service have implemented management plans for the species and have documented that management activities have eliminated threats to the species [USFWS 2012].

two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (e.g., mainstem and/or tributaries) such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 4,400 adults [USFWS 2012];

Recovery Priority Number: 14

Delisting Criteria:
When, through protection of the existing Citico Creek population and by introductions of the species back into Abrams Creek, viable populations exist in both creeks [USFWS 2012];

the U.S. Forest Service and National Park Service have implemented management plans for these two populations and have documented that management activities are successfully protecting and managing the species [USFWS 2012];

through introductions and/or discoveries of new populations, there exist viable populations in two other creeks within the species' historic range. (It is believed that at least two additional populations are required to ensure that the species will not become threatened in the foreseeable future) [USFWS 2012];

all four populations and their habitat are protected from present and foreseeable human related and natural threats that may interfere with the survival of any of the populations [USFWS 2012].

Recovery Actions:

- Determine the number of individuals required to maintain a viable population [USFWS 2012].
- Preserve Citico Creek population and presently used habitat of the smoky madtom [USFWS 1985].
- Search for additional populations [USFWS 1985].
- Determine the feasibility of reestablishing the smoky madtom back into its historic habitat in Abrams Creek, Great Smoky Mountains National Park, and to other suitable stream reaches that are determined to have been historic habitat [USFWS 1985].
- Assist the lead land management agency for each population in developing and implementing a program to manage the smoky madtom and monitor population levels and habitat conditions of the presently established populations as well as introduced populations [USFWS 1985].
- Annually assess overall success of the recovery program and recommend action (changes in recovery objectives, delist, continue to protect, implement new measures, other studies, etc.) [USFWS 1985].
- None developed; see Recovery Actions

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Continue stocking efforts in the Tellico River. • Continue to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations. • Conduct projects that would assess the efficacy of the genetic exchange and monitoring program for all populations and incorporate the Tellico River population into the genetic exchange program, as needed. • Continue efforts to reduce non-point pollution from agricultural activities in the Tellico River watershed by working through the Partners for Fish and Wildlife, Farm Bill, and other landowner incentive programs to implement best management practices. • Conduct studies to determine the extent and magnitude of impacts associated with recreational activities at CNF and GSMNP. • Continue to utilize existing legislation and regulations (Federal and state endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat. • Conduct controlled experiments to determine if Smoky Madtoms are sensitive to organic chemical pollution (e.g. phthalate ester) and to what degree. • Determine areas of the range in which organic chemical pollution is detrimental to Smoky Madtoms (USFWS, 2020)
- RECOMMENDED FUTURE ACTIVITIES Recovery Activities Continue to implement recovery actions identified in the Smoky Madtom Recovery Plan (Service 1985), such as assisting the USFS and the NPS in developing and implementing a program to manage the Smoky madtom and its habitat that improves and/or maintains the physical and biological conditions needed by the species and that promote long-term viability of the Smoky madtom. Continue implementation of the GSMNP translocation and genetic monitoring plan (Kulp et al., 2015). Monitoring / Research Activities Continue USFS sponsored annual monitoring programs to track populations in Citico Creek and Tellico River and assess the results and effectiveness of reintroduction efforts (USFS 2004). Continue

the long-term ecological monitoring programs at the GSMNP (e.g., All Taxa Biotic Inventory, Vital Signs, etc.) that aid in determining NPS-wide status and trends of macroinvertebrate and fish communities and assessing water quality and stream health of the GSMNP's freshwater resources (NPS 2016). Assess the feasibility and effectiveness of eDNA to inform our understanding of Smoky madtom occurrence outside of the three currently known populations. Aunins et al. (2022) concluded that the eDNA methodology they developed could be useful in future monitoring in the GSMNP and especially within habitat in the Little Tennessee River watershed that could potentially support Smoky madtoms.

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SPECIES ACCOUNT: *Noturus crypticus* (Chucky Madtom)

Species Taxonomic and Listing Information

Listing Status: Endangered; September 8, 2011; Southeast Region (R4)

Physical Description

The chucky madtom (Noturus crypticus) is a small catfish, with the largest specimen measuring 6.47 cm (2.55 in) SL (Burr et al. 2005, p. 795). Burr et al. (2005) described the chucky madtom, confirming previous analyses (Burr and Eisenhour 1994), which indicated that the chucky madtom is a unique species, a member of the Rabida subgenus (i.e., the ‘‘mottled’’ or ‘‘saddled’’ madtoms), and a member of the Noturus elegans species complex (i.e., N. elegans, N. albater, and N. trautmani) ascribed by Taylor (1969 in Grady and LeGrande 1992). A robust madtom, the chucky madtom body is wide at the pectoral fin origins, greater than 23 percent of the SL. The dorsum (back) contains three dark, nearly black blotches ending abruptly above the lateral midline of the body, with a moderately contrasting, oval, pale saddle anterior to each blotch (Burr et al. 2005, p. 795) (USFWS, 2010).

Taxonomy

The Chucky madtom is a rare catfish [USFWS 2012].

Historical Range

The Chucky madtom is historically known from two stream systems in eastern Tennessee (Dunn Creek, Sevier County and Little Chucky Creek, Greene County) and 15 individuals (USFWS, 2024).

Current Range

The current range of the Chucky madtom is restricted to an approximate 3-km (1.8-mi) reach of Little Chucky Creek in Greene County, Tennessee. It has not been observed since 2004 but is not presumed to be extirpated from Little Chucky Creek [USFWS 2012].

Distinct Population Segments Defined

No [inferred from USFWS 2012]

Critical Habitat Designated

Yes; 10/16/2012.

Legal Description

On October 16, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Noturus crypticus (Chucky Madtom) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Tennessee (77 FR 63604-63668).

Critical Habitat Designation

The critical habitat designation for Noturus crypticus includes one CHU in Greene County, Tennessee (77 FR 63604-63668).

Little Chucky Creek Unit, Greene County, Tennessee. (i) Little Chucky Creek Unit includes 31.9 river kilometers (19.8 river miles) of Little Chucky Creek from its confluence with an unnamed tributary, downstream to its confluence with the Nolichucky River, at the Greene and Cocke County line, Tennessee.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Noturus crypticus critical habitat consists of five components in Tennessee (77 FR 63604-63668):

(i) Gently flowing run and pool reaches of geomorphically stable streams with cool, clean, flowing water; shallow depths; and connectivity between spawning, foraging, and resting sites to promote gene flow throughout the species’ range.

(ii) Stable bottom substrates composed of relatively silt-free, flat gravel, cobble, and slab-rock boulders.

(iii) An instream flow regime (magnitude, frequency, duration, and seasonality of discharge over time) sufficient to provide permanent surface flows, as measured during years with average rainfall, and to maintain benthic habitats utilized by the species.

(iv) Adequate water quality characterized by moderate stream temperatures, acceptable dissolved oxygen concentrations, moderate pH, and low levels of pollutants. Adequate water quality is defined for the purpose of this rule as the quality necessary for normal behavior, growth, and viability of all life stages of the Chucky madtom.

(v) Prey base of aquatic macroinvertebrates, including midge larvae, mayfly nymphs, caddisfly larvae, and stonefly larvae.

Special Management Considerations or Protections

The single unit we are designating as critical habitat for the Chucky madtom will require some level of management to address the current and future threats to the physical and biological features of the species. The critical habitat unit is located on private property and is not presently under the special management or protection provided by a legally operative plan or agreement for the conservation of the species. Various activities in or adjacent to the critical habitat unit described in this rule may affect one or more of the physical and biological features. For example, features in this critical habitat designation may require special management due to threats posed by agricultural activities (e.g., row crops and livestock), lack of adequate riparian buffers, construction and maintenance of State and county roads, gravel mining, and nonpoint source pollution (e.g., agrochemicals, sediment) arising from a wide variety of human activities. These threats are in addition to random effects of drought, floods, or other natural phenomena. Other activities that may affect physical and biological features in the critical habitat unit include those listed in the Effects of Critical Habitat Designation section below. Management activities that could ameliorate these threats include, but are not limited to: Use of BMPs designed to reduce sedimentation, erosion, and bank side destruction; moderate application of agrochemicals; moderation of surface and ground water withdrawals to maintain natural flow regimes; increase of stormwater management and reduction of stormwater flows into the systems; preservation of headwater streams; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water. In summary, we find that the area we are designating as critical habitat for the Chucky madtom contains the physical or biological features for the species, and that these features may require special management considerations or protection. Special management consideration or protection may be required to eliminate, or to reduce to negligible levels, the threats affecting the physical or biological features of the unit.

Life History

Feeding Narrative

Adult: Include everything in previous columns in complete sentences

Reproduction Narrative

Adult: Include everything in previous columns in complete sentences

Geographic or Habitat Restraints or Barriers

Adult: Two riffle areas in the Little Chucky Creek [NatureServe 2015]

Spatial Arrangements of the Population

Adult: Clumped in two riffle areas that are adjacent to intact riparian buffers [NatureServe 2015]

Environmental Specificity

Adult: Broad/generalist [inferred from USFWS 2012]

Tolerance Ranges/Thresholds

Adult: Low; sensitive to water impairments [USFWS 2012]

Habitat Narrative

Adult: The Chucky madtom lives clumped in two riffle areas in Little Chucky Creek that are adjacent to intact riparian buffers. The habitat is a freshwater, benthic riverine environment [NatureServe 2015] with slow to moderate current over pea gravel, cobble, or slab-rock boulder substrates. The species is dependent on clean, cool flowing water; shallow depths; permanent surface flows; adequate water quality with substrates; connectivity between spawning, foraging, and resting sites; moderate stream temperatures; acceptable dissolved oxygen concentrations; and moderate pH. The species is a generalist with high ecological integrity of the community and a low tolerance for water impairment [USFWS 2012].

Dispersal/Migration

Motility/Mobility

Adult: Low [USFWS 2012]

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory [NatureServe 2015]

Dispersal

Adult: Low

Immigration/Emigration

Adult: No

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: The Chucky madtom exhibits low motility/mobility, is non-migratory, and experiences minimal dispersal. The species does not immigrate/emigrate and does not rely on other individuals or species for dispersal or migration [USFWS 2012].

Population Information and Trends

Population Trends:

Likely decreasing [NatureServe 2015]

Number of Populations:

1 (USFWS, 2024)

Population Size:

unknown, hasn't been found since listing (USFWS, 2024)

Adaptability:

Low [inferred from USFWS 2012]

Additional Population-level Information:

The species may be extirpated from Dunn Creek (Burr et al. 2005) and from locations in Alabama (Boschung and Mayden 2004) [NatureServe 2012].

Population Narrative:

The Chucky madtom is likely in decline, and may be extirpated from Dunn Creek and from locations in Alabama (Boschung and Mayden 2004) [NatureServe 2015]. The species shows low resiliency, representation, redundancy, and adaptability [inferred from USFWS 2012]. The Chucky Madtom is known from only one population in the Nolichucky River system. Since the species was listed as endangered in 2011, efforts to document its presence have not been successful. Habitat and water quality degradation remain the greatest threats to the species. Attempts at initiating captive propagation for the Chucky Madtom has been severely hampered by the difficulty in finding individuals for broodstock. The species remains highly vulnerable to extinction from stochastic events. (USFWS, 2019). The Chucky madtom is historically known from two stream systems in eastern Tennessee (Dunn Creek, Sevier County and Little Chucky Creek, Greene County) and 15 individuals. The Dunn Creek population is believed to be extirpated (Burr et al. 2005). At the time of the species description (2005), species experts believed the species to exist only in Little Chucky Creek at a very low density - probably fewer than 100 individuals (Burr et al. 2005). Currently, the species is thought to persist only in Little Chucky Creek, where a total of 14 individuals has been collected since 1991. None have been captured since 2004 despite considerable survey effort. An environmental DNA (eDNA) study of Little Chucky Creek is being conducted by the Tennessee Cooperative Fishery Research Unit at Tennessee Technological University in order to more thoroughly address this concern. Initial study results are expected during summer, 2024 (USFWS, 2024).

Threats and Stressors

Stressor: Sedimentation [USFWS 2012]
Exposure:
Response:
Consequence:
Narrative: Sedimentation could negatively affect the Chucky madtom by reducing growth rates, disease tolerance, and gill function; reducing spawning habitat, reproductive success, and egg, larval, and juvenile development; reducing food availability through reductions in prey; and reducing foraging efficiency [USFWS 2012].

Stressor: Physical habitat disturbance [USFWS 2012]
Exposure:
Response:
Consequence:
Narrative: Physical habitat disturbance could negatively affect the Chucky madtom in various ways [inferred from USFWS 2012].

Stressor: Contaminants (agrochemical discharges) [USFWS 2012]
Exposure:
Response:
Consequence:
Narrative: Contaminants associated with agriculture (e.g., fertilizers, pesticides, herbicides, and animal waste) can cause degradation of water quality and habitats through instream oxygen deficiencies, excess nutrification, and excessive algal growths [USFWS 2012].

Stressor: Vandalism
Exposure:
Response:
Consequence:
Narrative: Vandalism poses a threat but is not currently a stressor [inferred from NatureServe 2015]

Stressor: Random catastrophic events such as toxic chemical spills, drought, disease, or floods
Exposure:
Response:
Consequence:
Narrative: Random catastrophic events pose a threat but are not currently stressors [inferred from NatureServe 2015]

Recovery

Reclassification Criteria:
Recovery Priority Number: 5

Delisting Criteria:
1. Threats and causes of decline have been reduced or eliminated to a degree that the Chucky madtom does not need protection under the ESA (addresses Factor A and E). 2. Population studies show that a viable1 Chucky madtom population in Little Chucky Creek and at least 1

other stream (Dunn Creek, Jackson Branch; e.g., the only known stream representing the historical range of the species) are naturally recruiting and sustainable (addresses Factors A, C, and E) (USFWS, 2018).

Recovery Actions:

- 1. Capture and maintain Chuck y madtom broodstock. 2. Protect and enhance existing habitat in Little Chucky Creek. 3. Conduct life history studies on Chucky madtoms and/or surrogates. 4. Promote voluntary stewardship as a practical means of reducing nonpoint pollution from private land use and improving habitat. 5. Develop models to identify potential Chucky madtom habitat and potentiall y find new populations. 6. Develop and implement programs and materials to help inform the public about the Chuck y madtom 7. Coordinate all recovery activities, evaluate success, and revise recovery plan as appropriate (USFWS, 2018)
- RECOMMENDATIONS FOR FUTURE ACTIONS – The following recovery actions are in priority order and should be undertaken for the Chucky Madtom over the next five years: Priority 1 Actions Conduct surveys to document persistence of the Chucky Madtom. Capture and maintain Chucky Madtom broodstock to facilitate propagation of individuals for an ark population and conduct future population augmentation efforts. Protect, restore, and enhance existing habitat in Little Chucky Creek. Conduct life history studies on Chucky Madtoms and/or surrogate species. Priority 2 Actions Promote voluntary stewardship as a practical means of reducing nonpoint source pollution from private land use and improving habitat. Develop models to identify potential Chucky Madtom habitat and determine species presence at those sites. Develop and implement programs and materials to help inform the public about the Chucky Madtom. Coordinate all recovery activities, evaluate success of recovery efforts, and revise the recovery plan, as appropriate. (USFWS, 2019).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS – The following recovery actions are in priority order and should be undertaken for the Chucky Madtom over the next five years: Priority 1 Actions Conduct surveys to document persistence of the Chucky Madtom. Capture and maintain Chucky Madtom broodstock to facilitate propagation of individuals for an ark population and conduct future population augmentation efforts. Protect, restore, and enhance existing habitat in Little Chucky Creek. Conduct life history studies on Chucky Madtoms and/or surrogate species. Priority 2 Actions Promote voluntary stewardship as a practical means of reducing nonpoint source pollution from private land use and improving habitat. Develop models to identify potential Chucky Madtom habitat and determine species presence at those sites. Develop and implement programs and materials to help inform the public about the Chucky Madtom. Coordinate all recovery activities, evaluate success of recovery efforts, and revise the recovery plan, as appropriate. (USFWS, 2019)
- RECOMMENDED FUTURE ACTIVITIES A detailed recovery plan and criteria are presented in the Recovery Plan and Recovery Implementation (Service 2018b). Recovery activities include: creation of an ark (captive) population with broodstock, restoration and protection of existing riparian habitat in Little Chucky Creek, promotion of voluntary stewardship on private lands to reduce nonpoint source discharges, and implementing programs to raise public awareness about the species. Monitoring and research activities include: conducting life history studies on the Chucky madtom or its close relatives, expansion of monitoring beyond the known range of the species, developing models to identify other potential Chucky madtom habitat, and expanding monitoring to include night sampling and eDNA analysis. The eDNA study currently being conducted by the Tennessee Cooperative Fishery Research Unit is expected to provide initial information in addressing the need

for evidence of the species' presence or likely absence in 2024, and subsequent research will be conducted as determined necessary (USFWS, 2024).

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SPECIES ACCOUNT: *Noturus flavipinnis* (Yellowfin madtom)

Species Taxonomic and Listing Information

Listing Status: Threatened/Experimental Population, Non-Essential; 10/11/1977, 08/04/1988, 10/15/2007, 08/12/2002; Southeast Region (R4) (USFWS, 2016)

Physical Description

Noturus flavipinnis is a moderately elongated madtom (maximum known length 92 mm SL, ca 120 mm TL). It has a depressed head, large eyes, and a truncate to slightly rounded caudal fin. The pectoral spines are long with highly develop serrae. The fish's dorsal area is marked with four prominent dorsal saddles, a dark bar is present on the caudal fin base and near the caudal margin, while the dorsal fin has a medial stripe. Live specimens exhibit a yellowish tinge on the paler areas of the body, particularly the fins [USFWS 1983].

Taxonomy

This species is a small member of the catfish family [inferred from USFWS 1983].

Historical Range

The yellowfin madtom (Noturus flavipinnis) was probably once widely distributed in many of the lower gradient streams of the Tennessee River drainage upstream of the Chattanooga, Tennessee, area (Jenkins, 1975) [USFWS 1983]. The yellowfin madtom was historically known from only seven streams: South Chickamauga Creek, Catoosa County, Georgia; Clinch River, Tennessee; Hines Creek, a Clinch River tributary, Anderson County, Tennessee; North Fork Holston River, Smyth County, Virginia; Copper Creek, Scott and Russell Counties, Virginia; Powell River, Hancock County, Tennessee (and recently found in the Virginia portion of the river); and Citico Creek, Monroe County, Tennessee (USFWS 1983). Although there are no historical records from Abrams Creek, Blount County, Tennessee, Lennon and Parker (1959) reported that the brindled madtom (the name given by early collectors for the yellowfin) was collected during a reclamation project of lower Abrams Creek in 1957. Based on this observation, Dinkins and Shute (1996) and others concluded that the species once occurred in the middle and lower reaches of Abrams Creek [NatureServe 2015].

Current Range

The Yellowfin Madtom is known from three tributaries of the Little Tennessee River in Tennessee (Abrams Creek, Citico Creek, and the Tellico River), the Powell River in Tennessee and Virginia, the Clinch River and Copper Creek in Virginia, and the North Fork Holston River in Virginia (Table 2). On October 2, 2019, we received information from the Virginia Department of Game and Inland Fisheries indicating that a student at Virginia Tech had found at least one Yellowfin Madtom near a family campground on the Clinch River (approximately 8 miles downstream of the Copper Creek confluence). Surveys during the next field season will target this area to determine if the range of Yellowfin Madtoms in the Clinch River is larger than previously thought (J.R. Shute per. comm. 2019). (USFWS, 2020)

Distinct Population Segments Defined

Yes [inferred from USFWS 1983]

Critical Habitat Designated

Yes; 9/9/1977.

Legal Description
On September 9, 1977, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Noturus flavipinnis (Yellowfin Madtom) under the Endangered Species Act of 1973, as amended (42 FR 45526 - 45530). A Correction and Augmentation Final Rule was issued on September 22, 1977 (42 FR 47840-47845). The critical habitat designation includes two critical habitat units (CHUs), in Tennessee and Virginia .
The critical habitat designation for Noturus flavipinnis includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Noturus flavipinnis.

Critical Habitat Designation

The critical habitat designation for Noturus flavipinnis includes two CHUs, in Clairborne and Hancock Counties, Tennessee and Lee, Scott and Russell Counties, Virginia (47 FR 47840-47845).

Unit 1—Tennessee. Claiborne and Hancock Counties. Powell River, main channel from back-waters of Norris Lake upstream to the Tennessee-Virginia State line.

Unit 2—Virginia. Lee, Scott and Russell Counties. Powell River, main channel, from the Virginia-Tennessee State line upstream through Lee County. Copper Creek main channel from its junction with Clinch River upstream through Scott County and upstream in Russell County to Dickensonville.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Noturus flavipinnis critical habitat are not defined in the available Final Rules from 1977.

Life History

Feeding Narrative

Juvenile: The yellowfin madtom is an opportunist nocturnal invertivore that feeds primarily on aquatic insects and their larvae. At night the species moves out from its hiding places in search of food; however, if opportunity arises it is expected that the species will feed during daylight hours. Both tactile and chemical stimuli are used by the yellowfin in locating food [USFWS 1983].

Adult: The yellowfin madtom is an opportunist nocturnal invertivore that feeds primarily on aquatic insects and their larvae. At night the species moves out from its hiding places in search of food; however, if opportunity arises it is expected that the species will feed during daylight hours. Both tactile and chemical stimuli are used by the yellowfin in locating food [USFWS 1983].

Reproduction Narrative

Juvenile: The yellowfin madtom is oviparous [inferred from USFWS 1983]. The species reproduces sexually during their third summer. Spawning begins when water temperatures rise to 20-23C. Individuals may guard their eggs. The typical lifespan of an individual is 3 years, but some have been observed to live up to 5 yeasr. Spawning occurs May-July [NatureServe 2015]. Egg deposits have been observed under large slab rocks in higher gradient stream sections than the species normally occupies [USFWS 1983]. The species shows evidence of polyandry [USFWS 2012].

Adult: The yellowfin madtom is oviparous [inferred from USFWS 1983]. The species reproduces sexually during their third summer. Spawning begins when water temperatures rise to 20-23C. Individuals may guard their eggs. The typical lifespan of an individual is 3 years, but some have been observed to live up to 5 yeasr. Spawning occurs May-July [NatureServe 2015]. Egg deposits have been observed under large slab rocks in higher gradient stream sections than the species normally occupies [USFWS 1983]. The species shows evidence of polyandry [USFWS 2012].

Spatial Arrangements of the Population

Juvenile: Specimens were not observed in the riffle areas between pools [USFWS 1983].

Adult: Specimens were not observed in the riffle areas between pools [USFWS 1983].

Site Fidelity

Juvenile: Moderate [inferred from USFWS 1983]

Adult: Moderate [inferred from USFWS 1983]

Habitat Narrative

Juvenile: The yellowfin madtom habitat is small-medium freshwater creeks and streams [inferred from USFWS 1983]. The species prefers creeks and small rivers that are unpolluted, warm or warm to cool, usually relatively unsilted (Powell River may be very silty), and of moderate to gentle gradient. This species generally occurs in slow pools and occasionally small backwaters off runs and riffles. It is generally under cover during daylight hours. At night, it is often on the streambed in open clean gravel and rubble areas away from banks and riffles. It may occur in slightly to moderately silted bank areas during day or night. Eggs are laid in cavities beneath flat rocks in pools at depths of usually less than 1 meter. Individuals were not initially observed in the riffle areas between pools (USFWS 1983].

Adult: The yellowfin madtom habitat is small-medium freshwater creeks and streams [inferred from USFWS 1983]. The species prefers creeks and small rivers that are unpolluted, warm or warm to cool, usually relatively unsilted (Powell River may be very silty), and of moderate to gentle gradient. This species generally occurs in slow pools and occasionally small backwaters off runs and riffles. It is generally under cover during daylight hours. At night, it is often on the streambed in open clean gravel and rubble areas away from banks and riffles. It may occur in slightly to moderately silted bank areas during day or night. Eggs are laid in cavities beneath flat rocks in pools at depths of usually less than 1 meter. Individuals were not initially observed in the riffle areas between pools (USFWS 1983].

Dispersal/Migration

Motility/Mobility

Juvenile: Moderate [inferred from USFWS 1983]

Adult: Moderate [inferred from USFWS 1983]

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Non-migrant [inferred from USFWS 1983]

Adult: Non-migrant [inferred from USFWS 1983]

Dispersal

Juvenile: Moderate [inferred from USFWS 1983]

Adult: Moderate [inferred from USFWS 1983]

Dependency on Other Individuals or Species for Dispersal

Juvenile: Dispersal may be primarily a function of juvenile migration in a downstream direction [USFWS 1983].

Adult: Dispersal may be primarily a function of juvenile migration in a downstream direction [USFWS 1983].

Dispersal/Migration Narrative

Juvenile: The species exhibits moderate motility/mobility and is non-migrant. Dispersal is observed, and may be primarily a function of juvenile migration in a downstream direction [USFWS 1983].

Adult: The species exhibits moderate motility/mobility and is non-migrant. Dispersal is observed, and may be primarily a function of juvenile migration in a downstream direction [USFWS 1983].

Population Information and Trends

Population Trends:

No population trend data for the species over the past year; Citico Creek population appears to be stable [inferred from USFWS 2012].

Adaptability:

Low [inferred from USFWS 2012]

Additional Population-level Information:

Has been reintroduced into Abrams Creek and the Tellico River. Species rediscovered in the Clinch River [USFWS 2012]

Population Narrative:

While no population trend data existed prior to 2012, the Citico Creek population appears to be stable. The yellowfin madtom has been reintroduced into Abrams Creek and Tellico River, and has been rediscovered in the Clinch River [USFWS 2012].

Threats and Stressors

Stressor: Habitat alterations [USFWS 2012]

Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Physical habitat destruction resulting from a variety of human-induced impacts such as siltation, disturbance of riparian corridors, and changes in channel morphology continues to plague the Tennessee River watershed. The most significant of these impacts is siltation caused by excessive releases of sediment from activities such as agriculture, resource extraction (e.g., coal mining, silviculture), road construction, and urban development (Waters 1995). Activities that contribute sediment discharges into a stream system change the erosion or sedimentation pattern, which can lead to the destruction of riparian vegetation, bank collapse, excessive instream sediment deposition, and increased water turbidity and temperatures. [USFWS 2012]

Stressor: Sedimentation [USFWS 2012]
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Sediment has been shown to abrade and or suffocate bottom-dwelling organisms by clogging gills; reducing aquatic insect diversity and abundance; impairing fish feeding behavior by altering prey base and reducing visibility of prey; impairing reproduction due to burial of nests; and, ultimately, negatively impacting fish growth, survival, and reproduction (Waters 1995). Wood and Armitage (1997) identified at least five impacts of sedimentation on fish, including (1) reduction of growth rate, disease tolerance, and gill function; (2) reduction of spawning habitat and egg, larvae, and juvenile development; (3) modification of migration patterns; (4) reduction of food availability through the blockage of primary production; and (5) reduction of foraging efficiency. In addition, Etnier and Jenkins (1980) suggested that madtoms, which are heavily dependent on chemoreception (detection of chemicals) for survival, might be susceptible to human-induced disturbances, such as chemical and sediment inputs, because the olfactory (sense of smell) “noise” they produce could interfere with a madtom’s ability to obtain food and otherwise monitor its environment. The effects of these types of threats will likely increase as human populations grow in the Tennessee River watershed in response to human demands for water, housing, transportation, and places of employment. [USFWS 2012]

Stressor: Pesticides and pollutants [USFWS 2012]
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Non-point source pollution from land surface runoff can originate from virtually any land use activity (such as coal mining and agricultural activities) and may be correlated with impervious surfaces and storm water runoff from urban areas. Pollutants entering the Tennessee River watershed may include sediments, fertilizers, herbicides, pesticides, animal wastes, pharmaceuticals, septic tank and gray water leakage, and petroleum products. These pollutants tend to increase concentrations of nutrients and toxins in the water and alter the chemistry of affected streams such that the habitat and food sources for species like the yellowfin madtom and smoky madtom are negatively impacted. [USFWS 2012]

Stressor: Other anthropogenic activities (development) [USFWS 2012]
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.

Consequence: Not assessed; see narrative.
Narrative: Common land uses within the Clinch-Powell watershed include urban, industrial, commercial, and residential development; livestock production; agricultural cropping including tobacco and corn; coal mining, reclaimed coal mined lands, and “abandoned” coal mined lands (i.e., lands affected by mining prior to the federal law that were not reclaimed properly); road and railroad networks; and silvicultural practices (US EPA 2002). These land use activities act as sources of stress to the yellowfin madtom by contributing sediment and contaminants into the watershed. In June 2008, a car accident resulted in a gas spill that affected a small portion of Citico Creek in CNF in close proximity to where the yellowfin madtom and smoky madtom are known to exist. The accident occurred approximately 3.2 km (2 mi) upstream from designated critical habitat for the smoky madtom, and no investigation to officially quantify take was conducted for listed fishes. [USFWS 2012]

Stressor: Climate change (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative: Climate change has the potential to increase vulnerability of Yellowfin Madtom populations to random catastrophic events or alter habitat suitability within the species’ range. By the end of 2100, it is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales, and it is very likely that heat waves and extreme precipitation events will occur with a higher frequency and intensity (IPCC 2014). Projections for future precipitation trends in the southeastern U.S. are less certain than temperature projections; however, it is expected that there will be reduced water availability due to the increased evaporative losses (from increased transpiration from plants and evaporation from soils and water bodies) from rising temperatures alone (Carter et al. 2014). Warmer temperatures and decreased water availability will increase water temperatures, change runoff regimes, and increase the frequency, duration, and intensity of droughts in the southeastern United States (Kunkel et al. 2013). Reduced water availably may be a significant threat to the Yellowfin Madtom in the long term. In 2016, flows and water levels were exceptionally low for most of the late summer, with extreme drought conditions extending into November. Approximately a third to half of the Citico Creek channel was dry in late August (CFI 2017). (USFWS, 2020)

Stressor: Invasive crayfish (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative: In aquatic ecosystems, invasive crayfishes may cause biodiversity loss through competition for resources, reproductive interference, and predation (Gherardi 2010). TWRA and other biologists sampled the Clinch and Powell rivers in 2011 to document distribution of the Kentucky River crayfish (Faxonius juvenilis), a non-native crayfish in these watersheds (Bart Carter, per. comm. 2020). In that year, the species was not found upstream of the Hwy. 25E bridge (36.401980, -83.459170) in the Clinch River. However, the distribution of the Kentucky River crayfish has expanded since then. In 2019, Jeff Simmons collected the crayfish at Swan Island (Clinch River upstream of Swan Island, CRM 172.4. Hancock Co., 36.4779, -83.2895), which represents a significant expansion (Bart Carter, per. comm. 2020). TWRA and other biologists also documented a range expansion in the Powell River in 2019 from Kings Bend (36.500882, -

83.648925) to the Hwy 25E bridge (36.540610, -83.631411) (Bart Carter, per. comm. 2020). Currently, there is no direct evidence indicating that the Kentucky River crayfish is adversely impacting Yellowfin Madtoms, but the Service will take this potential threat into consideration if there are sudden changes in the Yellowfin Madtom's distribution, observed abundance, or reproduction. (USFWS, 2020)

Stressor: Small Population Size (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative: The Yellowfin Madtom is vulnerable to loss of genetic diversity and fitness due to small population sizes. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007). However, the effects of this threat are expected to be reduced through the gene exchange and monitoring program discussed in Section II.C.1.b. (USFWS, 2020)

Recovery

Reclassification Criteria:
Reclassification criteria not specified.
Reclassification criteria not specified.
Reclassification criteria not specified.
Reclassification criteria not specified.
Reclassification criteria not specified.
Reclassification criteria not specified.

Delisting Criteria:
When, through protection of existing populations and/or by introductions and/or discoveries of new populations there exist viable populations in the Powell River, Copper Creek, and Citico Creek [USFWS 1983];

through introductions and/or discoveries of new populations, there exist viable populations in two other rivers within the species' historic range. These populations should be at least as large as the smallset population in the aforementioned rivers [USFWS 1983];

noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River [USFWS 1983];

the species and its habitat in all five rivers are protected from present and foreseeable human related and natural threats that may adversely affect essential habitat or the survival of any of the populations [USFWS 1983].

Recovery Actions:
- Preserve populations and currently occupied habitat of the yellowfin madtom [USFWS 1983].
- Determine the feasibility of reestablishing the species in rivers within its historic range and introduce where feasible and necessary to meet recovery objectives [USFWS 1983].

- Conduct, on a need to know basis, life history studies not covered under section 1.2.2 above, i.e., age and growth, reproductive biology, longevity, natural mortality factors, and population dynamics [USFWS 1983].
- Investigate the necessity for habitat improvement and, if feasible and necessary to meet recovery, develop techniques and sites for habitat improvement and implement [USFWS 1983].
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations [USFWS 1983].
- Annually assess overall success of recovery program and recommend action (changes in recovery objectives, delist, continued protection, implement new measures, other studies, etc.) [USFWS 1983].
- None developed; see Recovery Actions

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS A. Continue population augmentation activities in the Tellico River and North Fork Holston River. B. Conduct surveys in the Clinch and Powell Rivers to determine range extent in these systems. C. Continue to monitor population levels and habitat conditions of presently established populations as well as introduced and expanding populations. D. Determine if qualitative night-time surveys would improve current population assessment methods. E. Conduct projects that replicate the Moyer and Williams (2012) study and assess the efficacy of the genetic exchange and monitoring program. F. Continue efforts to reduce non-point pollution from agricultural activities by working through Partners for Fish and Wildlife, Farm Bill, and other landowner incentive programs to implement best management practices. G. Continue planning and survey efforts to find better population augmentation locations in Copper Creek H. Continue to utilize existing legislation and regulations (Federal and state endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat. (USFWS, 2020)

References

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SPECIES ACCOUNT: *Noturus furiosus* (Carolina madtom)

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

Characteristic of all madtoms, the Carolina Madtom has its adipose fin fused to the caudal fin. It has a short, chunky body with well-developed dentations on both anterior and posterior edges of pectoral spines. Furiosus means “mad” or “raging”, as the Carolina Madtom is the most strongly armed of the North American catfishes with poison in the tips of the serrae that is more potent than that of any other species (Jordan 1889, p.352). The moderate-sized fish reaches a maximum length of nearly five inches, and has a distinct color pattern including three dark saddles (the adipose fin has a dark blotch that does not quite reach the fin’s edge, giving the impression of a fourth saddle) along its back and a wide black stripe along its side, extending from its snout to the base of its tail (Figure 2-1). In between the saddles are yellow/tan blotches, and the belly is not speckled. The tail has crescent-shaped brown bands near the edge and center. As in other species of the genus Noturus, there is no marked sexual dimorphism outside the breeding season (USFWS, 2018).

Taxonomy

The currently accepted classification is (Integrated Taxonomic Information System 2016): Phylum: Chordata Class: Actinopterygii Order: Siluriformes Family: Ictaluridae Genus: Noturus Species: Noturus furiosus (USFWS, 2018)

Historical Range

The Carolina Madtom is endemic to the Tar-Pamlico and Neuse River basins in North Carolina. Its historical distribution includes two physiographic provinces (Piedmont and Coastal Plain) comprising all major tributary systems of the Tar and Neuse (Burr and Lee 1985, p.1). Because of salt water influence, the habitats in the Trent River system are isolated from the Neuse River and its tributaries; therefore, we consider the Trent River system as a separate basin (i.e., population), even though it is technically part of the larger Neuse River Basin (USFWS, 2018).

Current Range

NC; For the purposes of this assessment, populations were delineated using the river basins that Carolina Madtoms have historically occupied. This includes the Tar, the Neuse, and the Trent River basins, and from here forward, we will use these terms to refer to populations (e.g., the Tar Population). Of the three historical Carolina Madtom populations, only two have observations in the last 5 years; the Carolina Madtom is presumed extirpated from the southern portion of the range in the Trent River basin. Because the river basin level is at a very coarse scale, populations were further delineated using management units (MUs). MUs were defined as one or more HUC10 watersheds that species experts identified as most appropriate for assessing population-level resiliency (see Section 3.3; Appendix A). Range-wide species occurrence data were used to create “occurrence heat maps” that discretize HUC10 watersheds into 5-year increments based on the date of observed occurrences (see GADNR 2016; Appendix B). These heat maps display recent observed occurrences using various shades of red, while older observed occurrences are displayed in various shades of blue (Figure 3-2). Documented species occurrences are included to show distribution within HUC10s and the NC Division of

Water Resources has documented sites where the Carolina Madtom is below detection ("X" in Figure 3-2), based on their most recent basin-wide fish surveys (NCDWR 2012 & 2015). Throughout this section, heat maps are used to characterize the historical and current distribution of Carolina Madtom among MUs for each of the three populations (USFWS, 2018).

Critical Habitat Designated

Yes; 7/9/2021.

Legal Description

We designate critical habitat for both species under the Act. For the Carolina madtom, approximately 257 river miles (mi) (414 river kilometers (km)) fall within 7 units of critical habitat in Durham, Edgecombe, Franklin, Granville, Halifax, Johnston, Jones, Nash, Orange, Vance, Warren, and Wilson Counties, North Carolina. For the Neuse River waterdog, approximately 779 river mi (1,254 river km) fall within 18 units of critical habitat in Craven, Durham, Edgecombe, Franklin, Granville, Greene, Halifax, Johnston, Jones, Lenoir, Nash, Orange, Person, Pitt, Wake, Warren, Wayne, and Wilson Counties, North Carolina. This rule extends the Act's protections to these species and their designated critical habitats. DATES: This rule is effective July 9, 2021 (USFWS, 2021).

Critical Habitat Designation

We designate critical habitat for both species under the Act. For the Carolina madtom, approximately 257 river miles (mi) (414 river kilometers (km)) fall within 7 units of critical habitat in Durham, Edgecombe, Franklin, Granville, Halifax, Johnston, Jones, Nash, Orange, Vance, Warren, and Wilson Counties, North Carolina. For the Neuse River waterdog, approximately 779 river mi (1,254 river km) fall within 18 units of critical habitat in Craven, Durham, Edgecombe, Franklin, Granville, Greene, Halifax, Johnston, Jones, Lenoir, Nash, Orange, Person, Pitt, Wake, Warren, Wayne, and Wilson Counties, North Carolina. This rule extends the Act's protections to these species and their designated critical habitats. DATES: This rule is effective July 9, 2021 (USFWS, 2021).

Tar Population Unit 1: TAR1—Upper Tar River Unit 1 consists of 26 mi (42 km) of the Upper Tar River, from the confluence with Sand Creek to the confluence with Sycamore Creek, in Granville, Vance, and Franklin Counties. Unit 1 is occupied by the species and contains all of the physical or biological features essential to the conservation of the species. The riparian land adjacent to the river is entirely privately owned. Special management considerations or protection may be required within this unit to address a variety of threats. Excessive amounts of nitrogen and phosphorus run off the land, or are discharged, into the waters, causing excessive growth of vegetation and leading to extremely low levels of dissolved oxygen. Based on 2014 data, seven stream reaches totaling approximately 38 miles (61.1 km) are ''impaired'' (as identified on the State's Clean Water Act section 303d list) in this basin. Indicators of impairment are low dissolved oxygen and low benthicmacroinvertebrate assessment scores, and the entire basin is classified as Nutrient Sensitive Waters (NCDEQ 2016, pp. 115–117). There are 102 nonmajor NPDES discharges, including several package wastewater treatment plants (WWTPs) and biosolids facilities, and 3 major NPDES discharges (Oxford WWTP, Louisburg WWTP, and Franklin County WWTP) in this unit; with expansion of these facilities, or addition of new wastewater discharges, an additional threat to habitat exists in this unit. Special management focused on agricultural and forestry BMPs, implementing highest levels of wastewater treatment practicable, maintenance of forested buffers, and connection of protected riparian corridors will benefit habitat for the species in this unit (USFWS, 2021). Unit 2: TAR2—Sandy/Swift Creek Unit 2 consists of 66 mi (106 km) of Sandy and Swift Creeks, located downstream from NC561 to the confluence with the Tar River, in Edgecombe, Vance, Warren, Halifax, Franklin, and Nash Counties. This unit is occupied and contains all of the physical or biological features essential to the conservation of the species. The riparian land adjacent to this unit is predominantly privately owned (96 percent), with some conservation parcels (2 percent) and State Game Lands (2 percent). Special management considerations or protection may be required within this unit to address a variety of threats. Excessive amounts of nitrogen and phosphorus run off the land, or are discharged, into the waters, causing excessive growth of vegetation and leading to extremely low levels of dissolved oxygen; one stream reach totaling approximately 5 miles (8 km) is impaired in this unit. Special management focused on agricultural and forestry BMPs, maintenance of forested buffers, and connection of protected riparian corridors will benefit habitat for the species in this unit. Unit 3: TAR3—Fishing Creek Subbasin Unit 3 consists of approximately 86 mi (138 km), including Fishing Creek from the confluence with Hogpen Branch to the confluence with the Tar River, and Little Fishing Creek from Medoc Mountain Road (SR1002) to the confluence with Fishing Creek, located in Edgecombe, Warren, Halifax, Franklin, and Nash Counties. This unit is occupied by the species and contains all of the physical or biological features essential to the conservation of the species. The riparian land adjacent to the unit is divided between privately owned parcels (89 percent), State Game Lands and State Park land (5 percent), and conservation parcels (6 percent). Special management considerations or protection may be required within this unit to address a variety of threats. Excessive amounts of nitrogen and phosphorus run off the land, or are discharged, into the waters, causing excessive growth of vegetation and leading to extremely low levels of dissolved oxygen. Special management focused on agricultural and forestry BMPs, maintenance of forested buffers, and connection of protected riparian corridors will benefit habitat for the species in this unit (USFWS, 2021). Unit 3: TAR3—Fishing Creek Subbasin Unit 3 consists of approximately 86 mi (138 km), including Fishing Creek from the confluence with Hogpen Branch to the confluence with the Tar River, and Little Fishing Creek from Medoc Mountain Road (SR1002) to the confluence with Fishing Creek, located in Edgecombe, Warren, Halifax, Franklin, and Nash Counties. This unit is occupied by the species and contains all of the physical or biological features essential to the conservation of the species. The riparian land adjacent to the unit is divided between privately owned parcels (89 percent), State Game Lands and State Park land (5 percent), and conservation parcels (6 percent). Special management considerations or protection may be required within this unit to address a variety of threats. Excessive amounts of nitrogen and phosphorus run off the land, or are discharged, into the waters, causing excessive growth of vegetation and leading to extremely low levels of dissolved oxygen. Special management focused on agricultural and forestry BMPs, maintenance of forested buffers, and connection of protected riparian corridors will benefit habitat for the species in this unit (USFWS, 2021).

Neuse River Population Unit 4: NR1—Upper Neuse River Subbasin (Eno River) Unit 4 consists of approximately 20 mi (32 km) of the Upper Neuse River extending from Eno River State Park downstream of NC70 to the confluence with Cabin Creek near Falls Lake impoundment, located in Orange and Durham Counties. This unit is not occupied by the species. There is one historical record of Carolina madtoms in this unit from 1961, but follow-up surveys in 2011 were not able to find any individuals. Although it is unoccupied, it does contain all of the physical or biological features essential for the conservation of the species. This unit is itself essential for the conservation of the species because it will provide for population expansion through propagation and reintroduction efforts, and will provide for resiliency in portions of known historical habitat that is necessary to increase the viability (resiliency, redundancy, and representation) of the species. Riparian land adjacent to the unit is almost entirely (79 percent) within State Park Lands, local government conservation parcels, and State Game Lands. Unit 5: NR2—Little River Unit 5 consists of 28 mi (45 km) of the Upper and Lower Little River from NC42 to Johnston/Wayne County line, located in Johnston County. This unit is occupied and contains all of the physical or biological features essential for the conservation of the species. The riparian land adjacent to the unit is predominantly privately owned (99 percent) with some (1 percent) State Conservation ownership. Special management considerations or protection may be required within this unit to address a variety of threats. Four stream reaches totaling approximately 17 miles are impaired in the Little River. The designation of impairment is based primarily on low benthic-macroinvertebrate assessment scores, low pH, and low dissolved oxygen. There are 32 non-major and no major NPDES discharges in this unit. Special management considerations in this unit include retrofitting stormwater systems, eliminating direct stormwater discharges, increasing and protecting existing open space, and maintaining connected riparian corridors. Unit 6: NR3—Contentnea Creek Unit 6 consists of approximately 15 mi (24 km) of Contentnea Creek from Buckhorn Reservoir to Wiggins Mill Reservoir, located in Wilson County. This unit is occupied by the species, and contains all of the physical or biological features essential for the conservation of the species. The riparian land adjacent to this unit is entirely privately owned. Special management considerations or protection may be required within this unit to address a variety of threats. Two stream reaches totaling approximately 21 miles are impaired in Contentnea Creek. The designation of impairment is based primarily on low benthic-macroinvertebrate assessment scores. There are 3 major and 77 nonmajor NPDES discharges in this unit. Special management considerations in this unit include retrofitting stormwater systems, eliminating direct stormwater discharges, increasing and protecting existing open space, and maintaining connected riparian corridors (USFWS, 2021).

Trent Population Unit 7: TR1—Trent River Unit 7 consists of approximately 15 mi (24 km) of the Trent River between the confluence with Cypress Creek and Beaver Creek, in Jones County. This unit is unoccupied by the species. The last known documentation of the species here was in 1986. Although it is unoccupied, this unit does contain all of the physical or biological features essential for the conservation of the species. This unit itself is essential for the conservation of the species because it will provide for population expansion through propagation and reintroduction, and will provide for resiliency in portions of known historical habitat that is necessary to increase the viability (resiliency, redundancy, and representation) of the species. All of the riparian land adjacent to this unit is privately owned (USFWS, 2021).

Primary Constituent Elements/Physical or Biological Features

We have determined that the following physical or biological features are essential to the conservation of Carolina madtom: (1) Suitable substrates and connected instream habitats, characterized by geomorphically stable stream channels and banks (i.e., channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation) with habitats that support a diversity of freshwater native fish (such as stable riffle-run-pool habitats that provide flow refuges consisting of silt-free gravel, small cobble, coarse sand, and leaf litter substrates) as well as abundant cover used for nesting. (2) Adequate flows, or a hydrologic flow regime (which includes the severity, frequency, duration, and seasonality of discharge over time), necessary to maintain instream habitats where the species is found and to maintain connectivity of streams with the floodplain, allowing the exchange of nutrients and sediment for maintenance of the fish’s habitat, food availability, and ample oxygenated flow for spawning and nesting habitat. (3) Water quality (including, but not limited to, conductivity, hardness, turbidity, temperature, pH, ammonia, heavy metals, and chemical constituents) necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages. (4) Aquatic macroinvertebrate prey items, which are typically dominated by larval midges, mayflies, caddisflies, dragonflies, and beetle larvae. We derive the specific physical or biological features essential to the conservation of Neuse River waterdog from studies of this species' habitat, ecology, and life history as described above. The primary habitat elements that influence resiliency of both species include water quality, water quantity, substrate, and habitat connectivity (USFWS, 2021).

Life History

Food/Nutrient Resources

Food Source

Adult: Burr observed that more than 95% of the food organisms in the Carolina Madtom stomachs were larval midges, mayflies, caddisflies, dragonflies and beetle larvae (Burr et al. 1989, p.78) (USFWS, 2018).

Lifespan

Adult: ~4 years (USFWS, 2018)

Breeding Season

Adult: The nesting season extends from about mid-May to late July (Burr et al. 1989, p.75) (USFWS, 2018).

Reproduction Narrative

Adult: Burr noted that female Carolina Madtoms reached reproductive maturity by 2 years, although the vast majority of gravid females observed were 3-year-olds (Burr et al. 1989, p.72). Age at first spawning for males is unknown, however males have been found guarding nests or nest sites at age 2-4 years, or longer than 2.5 inches. Females produce 80-300 eggs per breeding season (NCWRC 2009, p.2). Reproductively mature males have enlarged epaxial (dorsal) muscles, swollen lips, and swollen genital papillae. The swollen heads of males are presumed to help with nest guarding and possibly in nest preparation (Burr et al. 1989, p.72). Reproductively mature females have distended abdomens and swollen genital papillae. The nesting season extends from about mid-May to late July (Burr et al. 1989, p.75). Nest sites are often found under or in relic freshwater mussel shells (Figure 2-2), under large pieces of water-logged tree bark, or in discarded beverage bottles and cans partially buried on the stream bottom. Most nest sites are in runs above riffles or in pools with current (Burr et al. 1989, p.76). All nests with embryos or larvae are guarded by solitary males, 2 to 4 years old. Embryos adhere to one another in a mass but not to other surfaces, and clutch sizes average 152 larvae (Burr et al. 1989, p.76-77). Hatchlings exhibit tightly cohesive schooling behavior (Burr et al. 1989, p.78) (USFWS, 2018).

Habitat Type

Adult: Medium to large flowing streams of moderate gradient (USFWS, 2018)

Habitat Vegetation or Surface Water Classification

Adult: Freshwater; benthic riverine (USFWS, 2018)

Environmental Specificity

Adult: Moderate (inferred from USFWS, 2018)

Habitat Narrative

Adult: The Carolina Madtom is endemic to medium to large flowing streams of moderate gradient in both the Piedmont and Coastal Plain physiographic regions in the Neuse and Tar River basins (see Figure 3-1 below). Suitable instream habitats have been described as riffles, runs, and pools with current, and during the warm months the madtoms are found in or near swift current at depths of 1 to 3 feet (Burr et al. 1989, p.63). Juveniles inhabit slower currents, but some overlap with adults does occur. Stream bottom substrate composition is important for the benthic Carolina Madtom; leaf litter, sand, gravel, and small cobble are all common substrates associated with the species, although the species is most often found over sand mixed with pea-sized gravel and leaf litter (Burr et al. 1989, p.63; Midway et al. 2010, p.326; Figure 2-2). During the breeding season (May thru July), the Carolina Madtoms shift to areas of moderate to slow flow with abundant cover used for nesting (Burr et al. 1989, p.63) (USFWS, 2018).

Dispersal/Migration

Motility/Mobility

Adult: High (inferred from USFWS< 2018)

Population Information and Trends

Population Trends:

Decreasing (USFWS, 2018)

Resiliency:

Two of three populations known to be extant; currently extirpated from 7 of the 11 Management Units. Population status: 1 moderate resiliency, 1 very low resiliency (USFWS, 2018).

Representation:

Compared to historical distribution: 67% of river basin variability retained, however one population is in very low condition, one population is in moderate condition. Low genetic representation (due to very low abundances) in remaining populations. Limited physiographic variability in Piedmont and Coastal Plain (USFWS, 2018).

Redundancy:

Very low numbers in Neuse River population. Tar River population has three MUs currently occupied. Overall loss of 74% redundancy across range (8 out of 31 HUCs currently occupied) (USFWS, 2018).

Number of Populations:

Three (USFWS, 2021)

Adaptability:

We estimated that the Carolina madtom currently has low adaptive potential due to limited representation in two river basins and two physiographic regions. The species retains 33 percent of its known river basin variability, considering greatly reduced variability observed in the Neuse River population. In addition, compared to historical occupancy, the species currently retains very limited physiographic variability in the Coastal Plain (14 percent) and moderate variability in the Piedmont (56 percent) (USFWS, 2021).

Additional Population-level Information:

The range of the Carolina madtom has always been very narrow, limited to the Tar, Neuse, and Trent River drainages. Within the identified representation areas, the species retains redundancy within the Tar River population (three MUs currently extant); however, it has limited redundancy (two MUs extant) in the Neuse River population and no redundancy (extirpated) in the Trent River population. Overall, the species has lost 55 percent of its redundancy across its narrow, endemic range (USFWS, 2021).

Population Narrative:

The results of surveys conducted from 2011 to 2018 suggest that the currently occupied range of the Carolina madtom includes four MUs from two populations, corresponding to the Tar and Neuse River basins; however, only one population (Tar) has multiple documented occurrences within the past 5 years. The species has been extirpated from the southern portion of its range, including a large portion of the Neuse River basin and the entire Trent River basin. The Carolina madtom currently occupies 9 of the 31 historically occupied HUC10s (with ‘‘currently’’ defined as the observation of at least one specimen from 2011 to 2018), 7 of which are in the Tar River basin and 2 in the Neuse River basin. At the population level, the overall current condition (= resiliency) was estimated to be moderate for the Tar population, very low for the Neuse population, and likely extirpated for the Trent population (USFWS, 2021).

Threats and Stressors

Stressor: Development
Exposure:
Response:
Consequence:
Narrative: Development is listed as a Very High Conservation Concern (USFWS, 2018).

Stressor: Natural Systems Modifications
Exposure:
Response:
Consequence:
Narrative: Natural Systems Modifications are listed as Very High Conservation Concerns (USFWS, 2018).

Stressor: Agriculture and Forestry
Exposure:
Response:
Consequence:
Narrative: Agriculture and Forestry are listed as High Conservation Concerns (USFWS, 2018).

Stressor: Invasives
Exposure:
Response:
Consequence:
Narrative: Invasives are listed as High Conservation Concerns (USFWS, 2018).

Stressor: Pollution
Exposure:
Response:
Consequence:
Narrative: Pollution is listed as a High Conservation Concern (USFWS, 2018).

Recovery

Recovery Actions:

- Conservation management actions include in situ actions such as habitat protection and stream restoration as well as ex situ actions such as captive propagation, ultimately leading to species population restoration. “It is…widely recognized that the future of rare aquatic species is best secured by protecting and restoring biological integrity of entire watersheds” (Shute et al. 1997, p.448 and references therein). While land acquisition is the most obvious means of affecting watershed protection, it is not feasible to acquire entire watersheds. Shute et al. (1997, p.448) offer up “Ecosystem Management” as the most effective method of protecting the greatest number of species, however, they warn that “the complex nature of aquatic ecosystems and the watershed scale necessary for aquatic ecosystem protection is problematic... [It] is expensive, time consuming, and requires considerable coordination with and commitment from various agencies, organizations, and private individuals.” The Service and State Wildlife Agencies are working with numerous partners to make “Ecosystem Management” a reality, primarily by providing technical guidance and offering development of conservation tools to meet both species and habitat needs in aquatic systems in North Carolina. Land Trusts are targeting key parcels for acquisition, federal, state, and University biologists are surveying and monitoring species occurrences, and recently there has been increased interest in efforts to consider captive propagation and species population restoration via augmentation, expansion, and reintroduction efforts (USFWS, 2018).
- Recovery actions will focus on surveying for and monitoring populations of Carolina Madtom (including in areas that have not been surveyed recently), protecting high quality habitats in the Neuse and Tar-Pamlico River basins, improving population resiliency, and reducing threats to extant populations. The USFWS recommends initiating the following recovery actions immediately to address the Carolina Madtom’s survival and habitat needs, alleviate its primary threats, and fill information gaps critical to management. • Protect and acquire key habitats and riparian lands in high priority watersheds by leveraging partnerships with State and federal conservation agencies and land conservancies to help arrest and reverse population decline. High priority watersheds for this action include the currently occupied Upper Tar River, Sandy/Swift Creek and Fishing Creek subbasins in the Tar-Pamlico River basin and the Little River and Contentnea Creek watersheds in the Neuse River basin. • Continue refining captive propagation techniques and develop a population augmentation or reintroduction plan for strategically improving resiliency, redundancy, and

representation. • Develop a rangewide genetics project, including, a sequenced reference genome, refined population genetics, eDNA, and genetic tagging techniques, for use in monitoring and management, including informing propagation and population restoration efforts. Also consider the merits of developing a biobanking cryopreservation program, with techniques to properly conserve the Carolina Madtom's existing genetic diversity for future recovery efforts. • Identify and implement solutions for eliminating excessive sedimentation in designated critical habitats and for restoring habitat quality in areas where physical habitat degradation is a limiting factor. • Research the relationship of water quality parameters and pollutants to the presence, abundance, or recruitment of Carolina Madtoms to identify, prioritize, and alleviate water quality stressors contributing to decline and reduced population connectivity (e.g., wastewater or industrial effluent, contaminated runoff, thermal inputs, nutrient pollution or dissolved oxygen limitations). • Investigate the role of Flathead Catfish and other invasive species in the decline of the Carolina Madtom and develop strategies for addressing their impacts, especially within designated critical habitat units. • Ensure that the Carolina Madtom remains represented in both the Neuse and TarPamlico River basins by strategically devoting resources to population monitoring and habitat protection, and evaluate conditions in the Trent River for supporting relict or future populations. • Engage and educate local and State decision- and policy-makers, landowners, and government and industry professionals (e.g., those working in agriculture, wastewater, or stormwater management) about the species' needs and the contribution of urbanization and other land uses to existing stressors, and cooperate on developing remedies to reduce or alleviate the sources of these stressors. Focus engagement efforts in the municipalities and counties where critical habitat has been designated (Durham, Edgecombe, Franklin, Granville, Halifax, Johnston, Jones, Nash, Orange, Vance, Warren, and Wilson Counties, NC) and any that are also significant contributors to watershed-level effects on habitat (e.g., urbanization in Wake County, NC). • Identify physical barriers to gene flow and movement in designated critical habitats and prioritize and evaluate barriers for the possibility of removal (e.g., dams; abandoned temporary crossings) or remediation (e.g., repairing perched/undersized culverts; bridging; adding aquatic animal passage to dams). Barrier removal considerations also should account for the utility that some barriers may afford in preventing invasive species expansion or offering habitat stability. • Address the synergistic nature of multiple stressors (e.g., water quality, predation, connectivity, and global change factors) by identifying the most influential elements in each population management unit, continuously working cooperatively with partners to share information, and using modern tools (e.g., population/habitat modeling) to inform management and conservation efforts. (USFWS, 2021a)

Conservation Measures and Best Management Practices:

- Conservation Actions The USFWS and State wildlife agencies are working with numerous partners to provide technical guidance and are offering conservation tools to meet the needs of the Carolina Madtom. The following actions are currently in progress or completed, and they are expected to provide conservation benefits for the species. • Recent research funded by the North Carolina Wildlife Resources Commission (NCWRC) and conducted by partners at NC State University provided valuable data on occupancy and detection of the Carolina Madtom, their nonrandom selection of microhabitat, the use of artificial cover as a sampling technique and habitat enhancement, and population genetic structure (Cope 2018; Cope et al. 2019; Cope et al. 2021). This work advanced our understanding of the species' habitat needs, genetic representation, and sampling efficiency – all important contributions for informing conservation and management. • The USFWS has partnered with Conservation Fisheries, Inc., and the NCWRC on developing a captive breeding program for the Carolina Madtom, with funding from the National Fish and Wildlife Foundation. Efforts began in 2018 with the collection of wild fish as broodstock. Biologists at Conservation Fisheries, Inc., began exploring propagation techniques for this species. They had some success in producing and rearing young and have refined the process for increased survivorship of eggs and young. In 2021, Conservation Fisheries, Inc., produced a cohort of approximately 400 juvenile Carolina Madtoms for release into the wild. The NCWRC has plans to collect additional broodstock to ensure adequate genetic diversity in propagated fish. Successful captive breeding, augmentation of wild populations, and reintroduction into historically occupied habitats will be integral to the Carolina Madtom's recovery. • Together, the USFWS and NCWRC have drafted a programmatic Safe Harbor Agreement for 21 aquatic species that will support species restoration efforts, including population augmentation and reintroduction of the Carolina Madtom into historically occupied or other suitable habitats. The draft agreement is currently under review by staff at both agencies. • The USFWS and NC Department of Transportation have entered into a programmatic consultation agreement to minimize and mitigate impacts from bridge and culvert construction and maintenance activities. This program will reduce the regulatory burden of separate consultation for similar projects, ensure projects are conducted with appropriate methods for protecting instream habitat, and support recovery actions for the Carolina Madtom through fees. • Conservation land trusts are targeting parcels for acquisition in key watersheds occupied by the Carolina Madtom through their traditional operations and through funds and authorities related to a highway project and legal settlement. • The USFWS and the NC Forest Service have partnered to implement Foresters for Healthy Waters, a program that offers supplemental conservation assistance for landowners who want to implement enhanced aquatic habitat protection for rare and at-risk species. The two-year pilot program is underway in seven counties within the Carolina Madtom's range, and it may be continued and expanded if successful. (USFWS, 2021a)

- State and Federal Stream Protections (Buffers & Permits) A buffer is a strip of trees, plants, or grass along a stream or wetland that naturally filters out sediment and pollution from rain water runoff before it enters rivers, streams, wetlands, and marshes. North Carolina had buffer requirements in specific watersheds (1997-2015), including the Tar-Pamlico and Neuse, however, as described below, the NC Legislature enacted a Regulatory Reform effort, including "Riparian Buffer Reform" that allowed for the amendment of the buffer rules to allow/exempt development (see Session Law 2012-200, section 8 and Session Law 2015-246, House Bill 44, G.S. 143-214.23A (NCDEQ 2016a, entire)). Section 401 of the federal Clean Water Act (CWA) requires that an applicant for a federal license or permit provide a certification that any discharges from the facility will not degrade water quality or violate water-quality standards, including state-established water quality standard requirements. Section 404 of the CWA establishes a program to regulate the discharge of dredged and fill material into waters of the United States. Permits to fill wetlands and fill, culvert, bridge or re-align streams/water features are issued by the U.S. Corps of Engineers under Nationwide, Regional General Permits or Individual Permits. ● Nationwide Permits are for "minor" impacts to streams and wetlands, and do not require an intense review process. These impacts usually include stream impacts under 150 feet, and wetland fill projects up to 0.50 acres. Mitigation is usually provided for the same type of wetland or stream as what is impacted, and is usually at a 2:1 ratio to offset losses and make the "no net loss" closer to reality. ● Regional General Permits are for various specific types of impacts that are common to a particular region; these permits will vary based on location in a certain region/state. ● Individual permits are for the larger, higher impact and more complex projects. These require a complex permit process with multi-agency input and involvement. Impacts in these types of permits are reviewed individually and the compensatory mitigation chosen may vary depending on project and types of impacts. (USFWS, 2021b)

References

U.S. Fish and Wildlife Service. 2018. Species status assessment report for the Carolina Madtom (Noturus furiosus). Version 1.1. November, 2018. Atlanta, GA. U.S. Fish and Wildlife Service. 2021. Endangered and Threatened Wildlife and Plants

Threatened Species Status With Section 4(d) Rule for Neuse River Waterdog, Endangered Species Status for Carolina Madtom, and Designations of Critical Habitat. Final Rule. FR Vol. 86, No. 109. Pages 30688-30751.

USFWS. 2021. Endangered and Threatened Wildlife and Plants

Threatened Species Status With Section 4(d) Rule for Neuse River Waterdog, Endangered Species Status for Carolina Madtom, and Designations of Critical Habitat. Final Rule. FR Vol. 86, N0. 109. Pages 30688-30751.

U.S. Fish and Wildlife Service. 2018. Species status assessment report for the Carolina Madtom (Noturus furiosus). Version 1.1. November, 2018. Atlanta, GA.

USFWS. 2021a. Recovery Outline for Carolina Madtom (Noturus furiosus). 9 pp.

USFWS. 2021b. Species status assessment report for the Carolina Madtom (Noturus furiosus). Version 1.2. February, 2021. Atlanta, GA.

SPECIES ACCOUNT: *Noturus munitus* (Frecklebelly madtom)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

The frecklebelly madtom is a small, stout catfish with recorded body sizes reaching to 99mm (3.9 in) (Ethnier and Starnes 1993, pp 324). It is a member of the subgenus Rabida, and is a sister species to the Northern madtom (Noturus stigmosus), and piebald madtom (Noturus gladiator). Like other member of the subgenus Rabida, the frecklebelly madtom is distinctively marked with dark saddles, typically four for this species (Suttkus and Taylor 1965, pp. 171). This pattern helps to distinguish the frecklebelly madtom from other madtoms with which it co-occurs. The color of the frecklebelly madtom is a mixture of light yellows with brownish patches, which provides camouflage in its preferred habitats (Vincent 2019, unpaginated). It exhibits a lighter color with a combination of many scattered specks or freckles on the venter, which inspired its common name (USFWS, 2020).

Taxonomy

Kingdom—Animalia Phylum—Chordata Class—Actinopterygii Order—Siluriformes Family—Ictaluridae Genus—Noturus Subgenus—Rabida Species—Noturus munitus Common name—Frecklebelly Madtom USFWS, 2020

Historical Range

The historical range for the species includes the Pearl River system, eastern Louisiana and southern Mississippi; Tombigbee River, eastern Mississippi and western Alabama; upper Alabama and Cahaba rivers, central Alabama; Etowah River, northern Georgia; Conasauga River, northern Georgia and southeastern Tennessee (Bennett et al. 2008, pp. 464-467). It is believed that this species was historically more widespread in the Mobile Bay drainage but was extirpated from large river habitats after the creation of numerous impoundments (USFWS, 2020).

Current Range

The frecklebelly madtom occurs within the states of Alabama, Georgia, Louisiana, Mississippi, and Tennessee. It has a disjunct distribution across the Mobile Basin and Pearl River drainage, with populations in the Pearl River and Bogue Chitto River in the Pearl River drainage and the Upper Tombigbee, Alabama, Cahaba, Etowah, and Conasauga river systems in the Mobile River Basin (Figure 2.1; Piller et al. 2004, p. 1004; Bennett et al. 2010, pp. 507-508). Throughout its range, the frecklebelly madtom primarily occupies rivers within the Gulf Coastal Plain physiographic province; however, it occurs in the Ridge and Valley physiographic province in the Conasauga River and Piedmont Upland physiographic provinces in the Etowah River (Mettee et al. 1996, pp. 408-409). Physiographic provinces are regions divided into distinctive geographic areas based on physical geography, such as topography, soil type, and geologic history (Fenneman 1928, pp. 266-272). The Piedmont province contains lowlands (plains) and highlands (plateaus) with isolated mountains, and in Georgia, the elevation reaches up to 480 meters (1,500 feet) (Fennemann 1928, p. 293); the Ridge and Valley province contain a longitudinal series of valleys (lowlands) and ridges (mountains) through the Appalachians (USFWS, 2020)

Critical Habitat Designated

Yes; 4/3/2023.

Legal Description

We, the U.S. Fish and Wildlife Service (Service), determine threatened species status under the Endangered Species Act of 1973 (Act), as amended, for the Upper Coosa River distinct population segment (DPS) of the frecklebelly madtom (Noturus munitus), a fish species. We are also finalizing a rule under section 4(d) of the Act to provide for conservation of the species. In addition, we designate critical habitat for the Upper Coosa River DPS under the Act. In total, approximately 134 river miles (216 kilometers) in Georgia and Tennessee fall within the boundaries of the critical habitat designation.

Critical Habitat Designation

Critical habitat units are depicted for Bradley and Polk Counties, Tennessee, and Cherokee, Dawson, Forsyth, Lumpkin, Murray, and Whitfield Counties, Georgia.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of the Upper Coosa River distinct population segment (DPS) consist of the following components:

(i) Geomorphically stable, medium to large streams with: (A) Stable stream channels that maintain lateral dimensions, longitudinal profiles, and sinuosity patterns over time without an aggrading or degrading bed elevation; and (B) Banks with intact riparian cover to maintain stream morphology and reduce erosion and sediment inputs.

(ii) Connected instream habitats that: (A) Include stable riffle-run-pool complexes; (B) Consist of silt-free gravel, coarse sand, cobble, boulders, woody structure, and river weed (Podostemum spp.); and (C) Have abundant cobble, boulders, woody structure, or other suitable cover used for nesting.

(iii) Adequate flows, or a hydrologic flow regime (which includes the severity, frequency, duration, and seasonality of discharge over time), necessary to maintain instream habitats and to maintain connectivity of streams with the floodplain, allowing the exchange of nutrients and sediment for maintenance of the fish's habitat, food availability, and ample oxygenated flow for spawning and nesting habitat.

(iv) Appropriate water and sediment quality (including, but not limited to, conductivity; hardness; turbidity; temperature; pH; ammonia; heavy metals; pesticides; animal waste products; and nitrogen, phosphorus, and potassium fertilizers) necessary to sustain natural physiological processes for normal behavior, growth, and viability of all life stages.

(v) Diversity and availability of aquatic macroinvertebrate prey items, which include larval midges, mayflies, caddisflies, dragonflies, and beetles.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The features essential to the conservation of the Upper Coosa River DPS may require special management considerations or protections to reduce the following threats:

(1) Urbanization of the landscape, including (but not limited to) land conversion for urban and commercial use, infrastructure (roads, bridges, utilities), and urban water uses (water supply reservoirs, wastewater treatment)

(2) nutrient pollution from agricultural activities that impact water quantity and quality

(3) significant alteration of water quality

(4) culvert and pipe installation that creates barriers to movement

(5) other watershed and floodplain disturbances that release sediments or nutrients into the water or fill suitable spawning habitat

(6) creation of reservoirs that convert permanently flowing streams and/or streams that hold water into lake or pond-like (lentic) environments. Management activities that could ameliorate these threats include, but are not limited to, use of best management practices (BMPs) designed to reduce sedimentation, erosion, and bank-side destruction; protection of riparian corridors and suitable spawning habitat; retention of sufficient canopy cover along banks; moderation of surface and ground water withdrawals to maintain natural flow regimes; increased use of stormwater management and reduction of stormwater flows into the stream systems; placement of culverts or bridges that accommodate fish passage; and reduction of other watershed and floodplain disturbances that release sediments, pollutants, or nutrients into the water

Life History

Food/Nutrient Resources

Food Source

Adult: Aquatic insects (USFWS, 2020)

Reproductive Strategy

Adult: Oviparity

Lifespan

Adult: 3-5 years (USFWS, 2020)

Breeding Season

Adult: June-July (USFWS, 2020)

Reproduction Narrative

Adult: There is a lack of information and studies on the breeding behaviors of the frecklebelly madtom. Nesting biology and habitat has yet to be determined for frecklebelly madtoms, although data could potentially be inferred from closely related taxa. Reproduction is thought to occur between June and July (Trauth et al. 1981, p. 66). The female produces 50-70 eggs, which are released all at one time (Trauth et al. 1981, p. 66). The frecklebelly madtom is reproductively mature in the second summer after birth, similar to other madtom species (Burr and Stoeckel 1999, p. 65). Nesting sites for madtoms are typically cavities under natural material (rocks, logs, empty mussel shells) or human litter (inside cans or bottles, under boards). Madtoms construct cavities on the bottoms of streams by moving substrate using their heads to push gravel, or their mouths to carry gravel and pebble (Vincent 2018, unpaginated). Both males and females may construct nesting cavities (Burr and Stoeckel 1999, p. 69). A single male guards nests in least, elegant, smoky, and potentially frecklebelly madtoms (Mayden and Walsh 1984, p. 357; Dinkins and Shute 1996, pp. 56-58). Guardian males have empty stomachs, suggesting that they do not feed during nest guarding, which can last as long as 3 weeks (Dinkins and Shute 1996, pp. 56-58). In a study conducted on the Cahaba River, no nests of frecklebelly madtoms were observed. However, seasonal differences in sex ratios suggested that males likely moved to more difficult to sample habitat in pools to create and defend nests, while females remain more evenly dispersed among a variety of habitats (USFWS, 2020).

Habitat Type

Adult: Aquatic

Habitat Vegetation or Surface Water Classification

Adult: Fast moving water/weedy clumps of vegetation (USFWS, 2020)

Dependencies on Specific Environmental Elements

Adult: Dependent on large-river gravel shoal habitat (USFWS, 2020).

Geographic or Habitat Restraints or Barriers

Adult: Dams/Habitat alterations

Habitat Narrative

Adult: Primary habitat for frecklebelly madtom is associated with fast moving streams often associated with rivers and their tributaries, with substrate consisting of various sizes of gravel (Suttkus and Taylor 1965, pp. 177-178; Mettee et al. 1996, p. 409; Vincent, 2019, unpaginated). Cover is an important habitat factor for the species, as it provides for concealment against predators (Vincent, 2019, unpaginated), foraging habitat, and nesting habitat. Areas providing firm gravel substrates, such as small pebbles and rocks, are preferred, thus muddy waterways and still streams are not desirable habitat for this species (Suttkus and Taylor 1965, pp. 177; Taylor 1969, pp. 183; Mettee et al. 1996, p. 409; Piller et al. 2004, p. 1004). The presence or absence of coarse and stable gravel substrate is an important indicator of the occurrence of other madtom species. Simonson and Neves (1992, pp. 117-118) showed that the orangefin madtom N. gilberti occurred at localities with abundant gravel and cobble substrates, but was absent at sites dominated by silt or sand substrates. Gravel also is an important predictor for the occurrence of Ozark madtom N. albater (Mayden et al. 1980, p. 336) the mountain madtom N. eleutherus (Starnes and Starnes 1985, p. 333), and the pygmy madtom N. stanauli (Etnier and Jenkins 1980, pp. 17-22). However, results from surveys for the frecklebelly madtom in Alabama, Louisiana, and Mississippi suggest that the species will utilize streams dominated with sand substrates if suitable cover such as large woody debris is present (Wagner pers. comm. 2019). Aquatic vegetation appears to be an important habitat element for the frecklebelly madtom in some parts of its range. This species is often associated with permanent gravel shoals and riffles, and often found in or near aquatic vegetation, in small to large flowing streams and rivers (Taylor 1969, p. 183; Bennett et al. 2008, p. 459). Individuals occur in clumps of river weed (Podostemon) and under large, flat rocks (Taylor 1969, p. 183). In the upper Etowah and Conasauga rivers, frecklebelly madtoms have been collected in moderate to swift current over boulders, rubble, cobble, and coarse gravel and around concentrations of river weed (USFWS, 2020)..

Dispersal/Migration

Dependency on Other Individuals or Species for Dispersal

Adult: No

Population Information and Trends

Population Trends:

Stable to increasing (USFWS, 2020).

Number of Populations:

Documented in 29 watersheds within the last decade. 6 Representation Units. 16 Resiliency units (USFWS, 2020).

Additional Population-level Information:

The frecklebelly madtom can be abundant in appropriate habitat, and large collections (>300 individuals) have been made prior to habitat alteration in the Tombigbee River (USFWS, 2020).

Population Narrative:

Generally, it appears the number of occupied named streams has remained stable or increased through time. For populations to be resilient, the needs of individuals (flowing water, gravel substrate, and aquatic vegetation) must be met at a larger scale. Stream reaches with suitable habitat must be large enough to support a large enough reservoir of potential mates for frecklebelly madtom to breed with while avoiding issues associated with small population sizes, such as inbreeding depression. The frecklebelly madtom has been documented in 53 HUC10 watersheds across its range in Louisiana, Mississippi, Alabama, Georgia, and Tennessee, but has only been documented in 29 (55%) these of watersheds within the last decade (Albanese et al. 2018, p. 38; Fig. 2.2). The current range for the species includes: Pearl River drainage (Bogue Chitto River, Pearl River and tributaries downstream of Ross Barnett Reservoir in Jackson, MS); upper Tombigbee River drainage (East Fork, Buttahatchee River, lower Luxapallila Creek, Sipsey River); Alabama and Cahaba river drainages (lower Cahaba River, approximately downstream of Centreville, AL); Etowah River system (Etowah River upstream of Alatoona Reservoir);and the Conasauga River system (middle Conasauga River) (Bennett et al. 2010, p. 508). Recent surveys for the species have analyzed water samples for environmental DNA or eDNA (DNA that is shed from an organism, typically during its life). These surveys have reported frecklebelly madtom eDNA occurring in the Alabama River, lower Tombigbee River in Alabama and the Coosawattee River in Georgia (Freeman and Bumpers 2018, entire; Janosik and Whitaker 2018, entire, Rider et al. 2018, entire). These results suggest that the species persists in portions of its hypothesized historical range and expands our knowledge of its range into previously undocumented river reaches in the Tombigbee and Alabama rivers and the Coosawattee River. However, considerable uncertainty (arising from false positives, false negatives, DNA contamination, origin and fate of organismal sources of eDNA, etc.) can persist with this type of information (Cristescu and Hebert 2018 pp. 216-224) and methods need to be implemented to account for that uncertainty (Ficetola et al. 2015, pp. 551-554; Roussel et al. 2015, pp. 824-825; Wilson et al 2016, pp. 25-28; Cristescu and Hebert 2018 p. 224) For this assessment, we use eDNA data as evidence to support the hypothesis that the probability of the species being present in a particular river is greater than zero. We present a current known range for the species informed by occurrence data and eDNA. We only report rivers that have explicitly been identified to have evidence of eDNA or species observations as part of the range of the frecklebelly madtom. We hope to encourage additional discussion and research efforts from the scientific community on the potential populations that, until 2018, have not been reported as part of the documented range of the species in the lower Tombigbee, lower Alabama, and Coosawattee rivers (USFWS, 2020).

Threats and Stressors

Stressor: Agricultural practices (glyphosate use)
Exposure:
Response:
Consequence:
Narrative: Agricultural practices such as use of glyphosate-based herbicides for weed control and animal waste for soil amendment are becoming common in many regions, and pose threats to biotic diversity in freshwater systems. Over the past two decades, these practices have corresponded with marked declines in populations of fish and mussel species in the Upper Conasauga River watershed in Georgia/Tennessee (Freeman et al. 2017, p. 419). A study in this watershed showed that nutrient enrichment of streams was widespread with nitrate and phosphorus exceeding levels associated with eutrophication, and hormone concentrations in sediments were often above those shown to cause endocrine disruption in fish, possibly reflecting widespread application of poultry litter and manure (Lasier et al. 2016, entire). Researchers postulate that species declines observed in the Conasauga watershed may be at least partially due to hormones, as well as excess nutrients and herbicide surfactants (Freeman et al. 2017, p. 429).

Stressor: Development
Exposure:
Response:
Consequence:
Narrative: Urbanization is a significant source of water quality degradation that can reduce the survival of aquatic organisms, including the frecklebelly madtom. Urban development can stress aquatic systems in a variety of ways, including increasing the frequency and magnitude of high flows in streams, increasing sedimentation and nutrient loads, increasing contamination and toxicity, decreasing the diversity of fish, aquatic insects, plants, and amphibians, and changing stream morphology and water chemistry (Coles et al. 2012, entire; CWP 2003; entire). Sources and risks of an acute or catastrophic contamination event, such as a leak from an underground storage tank or a hazardous materials spill on a highway, increase as urbanization increases.

Stressor: Impoundments
Exposure:
Response:
Consequence:

Narrative: Impoundment of rivers is a primary threat to aquatic species in the southeast (Benz and Collins 1997, p. 22-23, 63, 91, 205, 273, 291, 397, 399, 401-406, 446); Buckner et al. 2002, 10-11). Dams modify habitat conditions and aquatic communities both upstream and downstream of an impoundment (Winston et al. 1991, pp. 103-104; Mulholland and Lenat 1992, pp. 193-231; Soballe et al. 1992, pp. 421-474). Upstream of dams, habitat is flooded and in-channel conditions change from flowing to still water, with increased depth, decreased levels of dissolved oxygen, and increased sedimentation. Sedimentation alters substrate conditions by filling in interstitial spaces between rocks which provide habitat for many species (Neves et al. 1997, p. 63-64), including the frecklebelly madtom. Downstream of dams, flow regime fluctuates with resulting fluctuations in water temperature and dissolved oxygen levels, the substrate is scoured, and downstream tributaries are eroded (Neves et al. 1997, p. 63-64; Schuster 1997, p. 273; Buckner et al. 2002, p. 11). Negative “tailwater” effects on habitat can extend many kilometers downstream (Neves et al. 1997, p. 63). Dams fragment habitat for aquatic species by blocking corridors for migration and dispersal, resulting in population isolation and heightened susceptibility to extinction (Neves et al. 1997, p.63-63). Dams also preclude the ability of aquatic organisms to escape from polluted waters and accidental spills.

Stressor: Invasive Species
Exposure:
Response:
Consequence:
Narrative: Invasive crayfishes have been suspected in the decline of native species, including the endangered Watercress Darter (Fluker et al. 2009, p. 193) and other madtom species, including the endangered Chucky Madtom (USFWS 2018, pp. 12-13) and the Mountain Madtom (Harris et al. in press, entire). Specific impacts to madtom species from invasive crayfish include competition for habitat and direct predation, especially early life stages (USFWS 2018, p. 13). In addition to overlapping diets (i.e. mainly macroinvertebrates), crayfish and madtoms require cavities for spawning and protection from predators, thus when habitat becomes limited, crayfish can have particularly detrimental impacts (Harris et al. in press, p. 4). Hydrilla is an aquatic plant that alters stream habitat, decreases flows, and contributes to sediment buildup in streams (NCANSMPC 2015, p.57). High sedimentation can cause suffocation and reduce stream flow necessary for madtom survival. Hydrilla is present in several watersheds where the frecklebelly madtom occurs. The dense growth is likely to alter the flow in these systems and cause sediment buildup, which could potentially alter the habitat for the frecklebelly madtom. While data are lacking on invasive crayfish or Hydrilla, they could potentially have negative impacts to frecklebelly madtom, and the spread of these invasive species is expected to increase in the future.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: In the southeast United States, several climate change models have projected more frequent drought, more extreme heat (resulting in increases in air and water temperatures), increased heavy precipitation events (e.g., flooding), more intense storms (e.g., frequency of major hurricanes increases), and rising sea level and accompanying storm surge (IPCC 2013, entire). When taking into account future climate projections for temperature and precipitation where frecklebelly madtom occurs, warming is expected to be greatest in the summer, which is

predicted to increase drought frequency, while annual mean precipitation is expected to increase slightly, leading to a slight increase in flooding events (Figures 3.1 and 3.2) (IPCC 2013, entire; Alder and Hostetler 2013, unpaginated; USGS 2020, unpaginated). Changes in climate may affect ecosystem processes and communities by altering the abiotic conditions experienced by biotic assemblages resulting in potential effects on community composition and individual species interactions (DeWan et al. 2010, p. 7). These changes have the potential to impact the frecklebelly madtom and its habitat.

Stressor: Poor water quality
Exposure:
Response:
Consequence:
Narrative: Watershed health within units was calculated using urban and agricultural land use information. Land cover data was compiled from the 2016 National Land Cover Dataset Version 1, accessed via the Multi-Resolution Land Characteristics (MRLC) consortium online. Increased agricultural land use within a watershed has the potential to increase nutrient and other pollutant loading to stream systems. In addition to other impacts on aquatic habitat structure and quality, urban cover increases runoff volume into streams, likely increasing loads of sediments, nutrients, metals, pesticides, and other nonpoint source pollutants (CWP 2003, entire). To establish current threat levels within a unit, we created thresholds of low, moderate, and high threats to frecklebelly madtoms. By creating current threat levels, we enable an assessment of the projected changes in the levels of these threats in future scenarios, as well as subsequent predictions about changes in resilience. The scaling of urban watershed impacts was derived from the Impervious Cover Model (ICM) and studies on amphibians and other taxa (Scheuler 1994, entire) which is widely used in planning and zoning. An updated model includes ranges of impervious cover likely impacting stream quality (Schuler et al. 2009, p. 313) and indicates good stream quality is <5-10% impervious cover, fair quality (i.e., impacted) ranges from 5-25% impervious cover, and poor quality occurs at >20-25% impervious cover within the watershed. Several other studies have found impacts of urbanization on biotic health occur at 8-12% impervious cover (Horner et al. 1997, entire; Wang et al. 2001 p. 259), although results from a recent study in the Etowah (Wegner et al. 2008, pp.1260-1261) indicate some species could become rare at impervious cover as low as 2%.

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

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Threatened Species Status With Section 4(d) Rule for the Upper Coosa River Distinct Population Segment of Frecklebelly Madtom and Designation of Critical Habitat. Final Rule. FR Vol. 88, No. 41. Pages 13038-13070.

SPECIES ACCOUNT: *Noturus placidus* (Neosho madtom)

Species Taxonomic and Listing Information

Listing Status: Threatened; 05/22/1990; Mountain- Prairie Region (R6)

Physical Description

A 2-inch catfish (madtom). Small (total length 8.7 cm), mottled dark- and light-brown, with dark bars on the tail fin; dorsal and anal fins have dusky streaks but are not black-tipped; dark blotch on adipose fin does not extend to margin (Cross and Collins 1995) (NatureServe, 2015).

Taxonomy

The Neosho madtom is a small member of the catfish family (Ictaluridae). The species was formally described by Taylor (1969), but had been recognized as a distinct species since the 1950s (Cross 1967). Prior to that, it was usually identified as brindled madtom (Noturus miurus), which also occurs in the Spring River, or mountain madtom (Noturus eleutherus), which is not found in the Neosho or Spring River drainages (USFWS, 2013).

Historical Range

Historically, the Neosho madtom range included the mainstem rivers of the Neosho and Spring River drainage system south to the Neosho's confluence with the Arkansas River in Oklahoma (the Neosho River is now referred to as the Grand River in Oklahoma). It was also known from the Illinois River in Oklahoma (USFWS, 2013).

Current Range

Species now occurs in about two-thirds of the historical range (see Bryan et al. 2004). Range includes part of the Arkansas River drainage: Spring River in southwestern Missouri and southeastern Kansas; Cottonwood and Neosho rivers in eastern Kansas and northeastern Oklahoma; lower Illinois River in east-central Oklahoma (at least formerly) (Bryan et al. 2004, Wildhaber 2006, Page and Burr 2011). This madtom is now found primarily in the Neosho and Cottonwood rivers of Kansas; it persists at low densities in a short stretch of the Neosho (Grand) River in Oklahoma upstream from Lake o' the Cherokees and in the Spring River in extreme southwestern Missouri and southeastern Kansas (Wilkinson et al. 1996) (NatureServe, 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Neosho madtoms feed on whatever aquatic insects are most readily available, principally the larvae of caddisflies, mayflies, and dipterans, with chironomids being most abundant in young-of-the-year fish (Moss 1981). Based on laboratory experiments, feeding activity is greatest within 3 hours of sunset (Moss 1981). In simulated stream habitat, Moss (1983) found that Neosho madtoms were intrusive into gravel substrate during the day, but moved about in search of food at night. They maintained contact with the substrate and seldom swam against even a moderate current for more than a few seconds (USFWS, 1991).

Reproduction Narrative

Adult: Spawning occurs May through July (Wildhaber 2008); usually during peak stream flow (Moss 1981, Cross and Collins 1995). One or both adults guard eggs. Three age classes have been reported, but Bulger and Edds (2001) found only two age classes, suggesting that madtoms breed at age 1 then die. Breeding adults use substrates that are more loosely compacted than those used by nonbreeding adults. Eggs are deposited in cavities under large objects in the substrate (Wildhaber 2008) (NatureServe, 2015). The Neosho madtom is a very short lived species, typically living one to two years. In 1996, Bulger et al. (1998) successfully spawned a pair of Neosho madtom in an aquarium. The pair utilized longitudinally divided pieces of plastic pipe for spawning and rearing, where the male guarded the eggs for nine to ten days, and young for eight to ten days (USFWS, 2013).

Geographic or Habitat Restraints or Barriers

Adult: Impoundments, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: 12 or less individuals per 100 square meters (NatureServe, 2015)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2013)

Habitat Narrative

Adult: This madtom inhabits permanent flow of medium-sized to moderately large, medium-gradient streams, moderate to strong currents; usually in fairly clear water under rocks in riffles with small, loosely packed gravel-pebble; sometimes in pools adjacent to riffles or near tree trunks in slack water downstream from riffles; non riffle occurrences may be most frequent during periods of low flow when riffles are not inundated (Wenke et al. 1992, Pflieger 1997). Juveniles use shallower areas with slower flow and looser substrates than do adults (Bulger and Edds 2001). Loosely compacted gravel bars are important components of the habitat (Bulger and Edds 2001). Overall density generally is not more than 12 per 100 square meters (Wenke et al. 1992). Separation barriers include dams/impoundments, high waterfalls, and upland habitat (NatureServe, 2015). The Neosho madtom is a benthic species. Most collections are made in the Spring and Neosho Rivers in shallow water, generally less than three feet deep (<1 m). Within these systems, no significant differences in madtom preferences for depth, velocity, and substrate size were found but gravel riffles with currents of one to four feet per second (<1.25 m/sec.) are preferred by adults (Moss 1981; Fuselier and Edds 1994; Wildhaber et al. 2000a). Overall, the availability of suitable substrate, water quality (including toxic metals), and aquatic invertebrates (prey items), and not interspecific competition, are the major influences on Neosho madtom population distribution and numbers (Wildhaber et al. 2000a; Wildhaber et al. 2000b) (USFWS, 2013).

Dispersal/Migration

Dispersal

Adult: Unknown (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Madtoms are generally regarded as sedentary, at least over the short term, but dispersal characteristics are unknown (NatureServe, 2015).

Population Information and Trends

Population Trends:

50 - 70% decline (NatureServe, 2015)

Number of Populations:

4 (USFWS, 2013)

Population Size:

1000 - 100,000 individuals (NatureServe, 2015)

Minimum Viable Population Size:

500 (USFWS, 1991)

Population Narrative:

Historical and current abundance in Missouri appear to be the same (Pflieger 1997). Declines have occurred in Oklahoma and Kansas. This species has experienced a long term decline of 50 - 70%. Total population is estimated at 1,000s - 10,000s. Occasionally this species is locally abundant (NatureServe, 2015). Since the Neosho madtom was listed, four generalized populations have been recognized (USFWS, 2013). Franklin (1980) estimated that a population of at least 500 individuals is needed to provide sufficient genetic variation for adaptation to changing environmental conditions (USFWS, 1991).

Threats and Stressors

Stressor: Impoundments (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The decline and imperilment of the Neosho madtom has been directly attributed to construction of numerous impoundments (Deacon 1961; Moss 1981; USFWS 1990; Wildhaber et al. 2000a). Dams eliminate river flow, trap silt, and increase sediment deposition within and upstream of the impounded areas. They alter water quality, increase bank and bed erosion, change hydrology and channel geomorphology, decrease habitat heterogeneity, affect normal flood patterns downstream, as well as block upstream and downstream movement of fishes (USFWS 1990; Cross and Collins 1995; Tiemann et al. 2004a; Gillette et al. 2005). Within impounded waters, loss of fish diversity is directly attributed to loss of supporting habitat, sedimentation, decreased dissolved oxygen, temperature levels, and alteration in resident fish populations (USFWS 1990; Cross and Collins 1995). Downstream of dams, declines in some species are associated with changes and fluctuation in flow regime, channel scouring and bank erosion, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages (Moss 1981; USFWS 1990; Wildhaber et al. 2000a; Bryan et al. 2010). Dam construction has a secondary effect of fragmenting the ranges of fish species, leaving habitats

and populations isolated upstream or between structures as well as creating extensive areas of deep, uninhabitable impounded waters. These isolated populations thus become unable to naturally recolonize suitable habitat from downstream effectively isolating populations and reducing genetic heterozygocity (Allendorf and Luikart 2007), making the species more prone to further extirpation from stochastic events, such as severe drought, accidental chemical spills, or unauthorized discharges (Moss 1981; USFWS 1991; Wildhaber 2011). The Neosho madtom is presently impacted by four major impoundments in the Neosho and Cottonwood River systems and two impoundments on the Spring River (USFWS, 2013).

Stressor: Reservoir operations and hydrologic changes (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Flow changes limit available suitable habitat for the species, increase consolidation of gravels on bars and riffles (decreasing their suitability as habitat for the Neosho madtom), and alter the substrate composition in the stream reach nearest the dam to sizes not typically used by the species. The operation of John Redmond Dam appears to impact the species in abundance, habitat quality, and quantity (USFWS, 2013).

Stressor: Gravel mining (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Mining within and adjacent to the flowing channel can directly remove occupied fish habitat; remove all temporally used habitat (habitat used at higher water levels) at a given location; as well as release large plumes of silt and other sediment downstream, degrading habitat quality; encourage increased erosion and head-cutting upstream; and directly cause mortality to fishes and other aquatic organisms by operation of heavy equipment in channel (Brown et al. 1998). As unregulated scalping of gravel bars increases over time, the level of threat from decreased availability of gravel which encompasses the species' habitat will likely increase as well (USFWS, 2013).

Stressor: Water quality (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: The Neosho Madtom Recovery Plan (1991) recognized several specific threats to water quality potentially impacting the species, including feedlot pollution, non-point source pollution, mine waste contamination, and operation of the Wolf Creek Nuclear Power Generating Station. Confined animal feeding operations (CAFOs) can accidentally release of large volumes of animal waste from sewage lagoons, threatening the Neosho madtom by severely impacting ammonia and oxygen levels in streams. While continuing threats exist from CAFOs, the large industrial feeding operations that caused the major problems in the past have relocated out of the region, leaving predominantly smaller (<200 cattle), largely unregulated CAFOs. The increased nutrient load can cause blooms of algae in shallow water over gravel bar habitat, decreasing supportive habitat and water quality for the Neosho madtom (USFWS 1991). Cattle in some areas also use the rivers as a source of drinking water. Increased erosion through trampling by cattle of stream-side vegetation and increased nutrient load through defecation create

localized impacts on Neosho madtom. Non-point source pollution from land surface runoff can originate from virtually any land use activity. Across the Neosho madtom's range, typical sources are row-crop agriculture, road and bridge construction, urban and rural development, and removal of riparian vegetation. Pollutants entering the Neosho and Spring Rivers include sediments, fertilizers, herbicides, pesticides, animal wastes, pharmaceuticals, solid wastes, septic tank leakage, and petroleum products. Sediment has been shown to damage and or suffocate bottom-dwelling organisms by clogging gills; reducing aquatic insect diversity and abundance; impairing fish feeding behavior by altering prey base and reducing visibility of prey; impairing reproduction due to burial of nests; and, ultimately, negatively impacting fish growth, survival, and reproduction (Waters 1995). Fishes of the Spring River, including the Neosho madtom, are limited by lead, zinc, and cadmium in water and benthic invertebrate food sources downstream of the confluence of Turkey Creek (Allert et al. 1997; Wildhaber et al. 2000b) (USFWS, 2013).

Stressor: Drought (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: Drought in the prairie landscape is a natural phenomenon historically tolerated by the Neosho madtom in unaltered habitat. Drought has an increasing impact on the species as water demands increase and watershed development and land-use changes occur. These impacts have resulted in decreased connectivity and increased isolation of existing populations as surface flows decrease or cease. In its natural environment, the Neosho madtom was able to disperse to suitable, although likely less than optimal, habitat during dry periods. Presently, the numerous major and lowhead dams in the system greatly decrease this ability. Much of the species' remaining range is fragmented under ideal flow conditions, and the occurrence of drought exacerbates this threat (USFWS, 2013).

Stressor: Climate change (USFWS, 2013)
Exposure:
Response:
Consequence:
Narrative: If climate change models prove accurate, the long-term impacts to the Neosho madtom could be substantial. Impacts in summer are of particular concern. Increased air temperatures will lead to higher water temperatures, especially during low-flow periods. Reduced summer precipitation and increased evaporation is likely to reduce flows. Such conditions cause increased stress to fish. The timing and amount of precipitation will also impact groundwater recharge rates. Finally, substantially hotter summers would likely increase municipal and agricultural demand for surface-water and ground-water resources. Thus, the available information indicates climate change is a substantial long-term risk factor which could meaningfully impact water quantity and the suitability of stream habitat (USFWS, 2013).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:

1. The appropriate number of viable, self-sustaining populations has been documented in the three regions occupied by this species (USFWS, 1991).

2. Enhanced legal protection for these populations at the State level and sufficient biological information to properly manage this species shall be obtained (USFWS, 1991).

Recovery Actions:
- Conduct studies on biology of Neosho madtoms to determine criteria to be used for delisting (USFWS, 1991).
- Develop criteria to be used for delisting (USFWS, 1991).
- Monitor populations of the Neosho madtom (USFWS, 1991).
- Develop Neosho madtom reintroduction plans (USFWS, 1991).
- Enhance protection of Neosho madtom populations and habitat (USFWS, 1991).
- Complete surveys for Neosho madtom in unsurveyed areas (USFWS, 1991).
- Communicate and coordinate with the U.S. Army Corps of Engineers concerning possible detrimental impacts to the Neosho madtom by operations of John Redmond Dam; and to encourage initiation of section 7 consultation under the ESA resulting in changes in dam operations (USFWS, 2013).
- Continue to develop and fund a population genetics studies to identify possible genetic loss and differentiation of populations pertinent to a new draft recovery plan and its implementation (USFWS, 2013).
- Develop a new draft and final recovery plan for the Neosho madtom, including objective, measurable recovery criteria (USFWS, 2013).
- Continue to implement standardized annual monitoring for the species and its habitat, resulting in information to track changes in abundance, distribution, and trends (USFWS, 2013).
- Continue efforts and coordination with other agencies, municipalities, and landowners to encourage removal of lowhead dams in the species' watersheds (USFWS, 2013).
- Continue to use existing legislation and regulations (federal and state endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat (USFWS, 2013).
- Continue efforts to reduce non-point source pollution by working through the Partners for Fish and Wildlife Program, the Farm Bill, the Watershed Restoration and Protection Strategy (WRAPS), and other incentive programs to implement best management practices (USFWS, 2013).

Conservation Measures and Best Management Practices:
- Recommendations for Future Actions: 1. Communicate and coordinate with the U.S. Army Corps ofEngineers (Corps) concerning potential impacts to the Neosho madtom due to the operation ofthe John Redmond Dam. Consider consulting with the Corps on changes to the dam operations that could benefit the species. 2. Continue to develop and fund a population genetics study to investigate the possible genetic loss and differentiation of populations, which would also help inform a new draft recovery plan for the species. 3. Work with partners to draft a new recovery plan for the Neosho madtom which would include objective and measureable recovery criteria. 4. Continue to monitor the species and its habitat annually using standardized methods to help inform evaluations of abundance, distribution, and trends. 5. Continue to coordinate with other agencies, municipalities, and landowners to encourage the removal oflowhead dams in watersheds with

Neosho madtoms. 6. Continue efforts to reduce non-point source pollution by working through the Farm Bill, the Watershed Restoration and Protection Strategy (WRAPS), and other incentive programs to implement best management practices within the Neosho river's watershed when opportunities exists. (USFWS, 2020)

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SPECIES ACCOUNT: *Oncorhynchus aguabonita whitei (=O. mykiss whitei)* (Little Kern golden trout)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Threatened; April 13, 1978 (43 FR 15427).

Physical Description

The Little Kern golden trout (Oncorhynchus aguabonita whitei [=O. mykiss whitei]) is a member of the Salmonidae (trout and salmon) family. It is a brightly colored fish with profuse spots on the back and tail. The belly and cheeks are red to red-orange. The lower sides are bright gold. The lateral band is red-orange. The back is olive green. Pectoral, pelvic, and anal fins are orange, with white tips. Little Kerns typically retain up to ten parr marks (vertical dark oval spots) on each side as adults. They average about 13 to 19 centimeters (cm) (5 to 7 inches [in.]) in length (USFWS 2007).

Taxonomy

The Little Kern golden trout was originally listed as Salmo aguabonita whitei; however, all western North American trout have been reclassified from the genus Salmo to the genus Oncorhynchus. The list of threatened and endangered wildlife was updated to conform to this change in the nomenclature (USFWS 2011). The Little kern golden trout (Oncorhynchus mykiss whitei) is one of three subspecies of rainbow trout (O. mykiss) native to the Kern River basin. The two other native subspecies include the California golden trout (O. mykiss aguabonita) and the Kern River rainbow trout (O. mykiss gilberti). There has been historic debate on the taxonomy of golden trout in the Kern River basin. Originally, three species of trout were described: Salmo whitei from the Little Kern River, Salmo aguabonita from the South Fork Kern River, and S. roosevelti from Golden Trout Creek. In addition, Kern River rainbow trout (Salmo gairdneri gilberti) was determined to be a subspecies of rainbow trout. Little Kern golden trout were later recognized as a subspecies of S. aguabonita, and its taxonomic name was changed to S. aguabonita whitei. However, most recently, genetic studies have indicated that the Little Kern golden trout and the other trout of the basin are subspecies of rainbow trout (O. mykiss) (USFWS 2011). The Little Kern golden trout is distinguishable from the South Fork of the California golden trout primarily by spotting characteristics and parr marks. Unlike the South Fork subspecies, the Little Kern typically has many spots on the head and below the lateral line. The parr marks are arranged vertically on both sides of the body, with an intermediate row of smaller ones often occurring just below the main row (USFWS 2007).

Historical Range

The Little Kern golden trout is endemic to the Little Kern River drainage in Tulare County, California. The Little Kern River drainage occurs primarily in the Golden Trout Wilderness of Sequoia National Forest. Smaller areas of the drainage occur in either Sequoia National Park or the Sequoia National Forest. Successive invasions of ancestral redband rainbow trout between 10,000 and 20,000 years ago allowed the Little Kern golden trout to become established in isolation from other salmonids and evolve into its current subspecies form. These primitive redband trout gained access to the Kern River drainage during glacial cycles and short-term interglacial wet cycles that allowed Lake Tulare to overflow and connect the Kern River drainage to the San Joaquin River and Pacific Ocean (USFWS 2011). Historically, the Little Kern golden trout occupied approximately 160 kilometers (km) (99.4 miles [mi.] of the Little Kern River and tributaries. At the time of its listing in 1978, the range of the Little Kern golden trout had been drastically reduced to approximately 16 km (9.9 mi.) of stream, or 10 percent of its historical range, and contained fewer than 5,000 individuals. Range reductions resulted from the introduction of coastal rainbow trout and subsequent hybridization with Little Kern golden trout, beginning in the early 1900s (USFWS 2011).

Current Range

By 1973, the range of the Little Kern golden trout was reduced to five headwater streams (upper Soda Springs Creek, Deadman Creek, lower wet meadows creek, Willow Creek, and Fish Creek) and an introduced population in Coyote Creek (USFWS 2011). Between 1974 and 1995, a series of chemical treatments was conducted by the California Department of Fish and Wildlife in an effort to remove introgressed Littler Kern golden trout populations throughout the basin (USFWS 2011). The distribution of Little Kern golden trout is currently almost entirely restricted to the Little Kern River and its tributaries (USFWS 2011). The exact current range of Little Kern golden trout is difficult to ascertain because, although highly introgressed populations were chemically removed, restocked populations continue to exhibit rainbow trout alleles at low, moderate, and even high levels (USFWS 2011). Critical habitat for the species includes the main channel and all streams tributary to the Little Kern River above the barrier falls on the Little Kern River, 1.6 km (1 mi.) below the mouth of Trout Meadows Creek, Tulare County, California (43 FR 15427).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 4/13/1978.

Legal Description

On April 13, 1978 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Oncorhynchus aguabonita whitei (Little Kern golden trout) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in California (43 FR 15427-15429).

The critical habitat designation for Oncorhynchus aguabonita whitei includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Oncorhynchus aguabonita whitei.

Critical Habitat Designation

The critical habitat designation for Oncorhynchus aguabonita whitei includes one CHU in Tulare County, California (43 FR 15427-15429).

(1) California, Tulare County - Little Kern River, main channel and all streams tributary to the Little Kern River above barrier falls located on the Little Kern River one mile below the mouth of Trout Meadows Creek.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (43 FR 15427-15429):

(1) The streams included in the Little Kern River watershed determined to be Critical Habitat include sufficient area for individual and population growth and dispersal of the Little Kern golden trout. The pools in stream areas within the designated area are proper habitat for aquatic insects which provide food for the trout. The cobbles and larger rocks provide cover for both juvenile and adult fish. The gravel bottom in pool areas of the Critical Habitat streams provides proper substrate for the excavation of nest. The Little Kern River is the only known habitat of the Little Kern golden trout.

Life History

Feeding Narrative

Adult: The Little Kern golden trout is an opportunistic invertivore. The diet of Little Kern golden trout consists mainly of surface water-dwelling insects, principally small ones such as caddisflies and midges. Small crustaceans such as tiny freshwater shrimp as well as some terrestrial insects contribute to the diet as well. However, small insects, either in larvae or fully developed form, floating on the surface compose most of the natural food of this subspecies (USFWS 2015). Brook trout (Salvelinus fontinalis) were introduced for angling, and are competitively superior to Little Kern golden trout (USFWS 2011).

Reproduction Narrative

Adult: Little Kern golden trout spawn between May and June, depending on water temperature; spawning typically coincides with the snowmelt recession. Both males and females turn bright orange during spawning, with a decrease in coloration post-spawn. The male generally establishes the spawning site territory, while the female selects the redd (spawning nest) location after courtship. Spawning sites are usually in the area of a pool-tail crest with a water depth of 5 to 15 cm (2.0 to 5.9 in.), substrate measuring between 5 to 15 mm (0.2 to 0.6 in.), sufficient cold water and flow to remove silt and fine sediments, and close proximity to cover. The act of spawning can last anywhere from 2 to 7 days; females produce between 41 and 65 eggs during spawning, which is low compared to other salmonids. Low egg production could be attributed to harsh environmental conditions and/or the small body size of these fish. Average development time of eggs is approximately 26 days at water temperatures varying between 12 and 16 °C (54 and 61 °F). Alevins remain in bed substrate for about 14 days (USFWS 2011).Little Kern golden trout typically reproduce after 3 to 4 years, but some have been shown to mature as early as age two. Little Kern golden trout commonly live until age six or seven or longer. This is extremely old for stream-dwelling trout, and is likely due to the short growing season, high densities of fish, and a low abundance of food in these streams. These conditions create competition for scarce resources, promoting slow growth rates and old ages of trout due to the minimal energetic costs that are expended in low temperatures in conjunction with food depletion (USFWS 2011).

Geographic or Habitat Restraints or Barriers

Adult: Natural and man-made barriers (e.g., waterfalls or dams).

Spatial Arrangements of the Population

Adult: Adult fish tend to select pool habitats, while juvenile fish occupy shallower habitats with higher stream velocities (USFWS 2011).

Environmental Specificity

Adult: Community with key requirements common.

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: Little Kern golden trout depend on pools in stream areas, which are habitat for aquatic insects that provide food for the trout (43 FR 15427).

Habitat Narrative

Adult: Little Kern golden trout inhabit the Little Kern River and its tributaries, which are characterized as a high-gradient system constructed of bedrock canyons, with some alluvial segments occurring at lower elevations. Little Kern golden trout occupy habitats between about 2,700 and 3,700 m (9,000 and 12,000 ft.) in elevation (USFWS 2015). Riparian vegetation can be limited on the Little Kern River and its tributaries, which is, at least in part, due to livestock grazing. However, patches of sedges and willows (Salix sp.) exist with transition to upland zones dominated by Jeffrey pine (Pinus jeffreyi), lodgepole pine (P. contorta), and ponderosa pine (P. ponderosa). Movement of Little Kern golden trout is limited by natural and man-made barriers (e.g., waterfalls or dams) (USFWS 2011).Little Kern golden trout use a variety of habitats within this range, including lateral scour pools, plunge pools, riffles, and undercut banks. Adult fish tend to select pool habitats, while juvenile fish occupy shallower habitats with high stream velocities. Other habitat features that can serve as cover for Little Kern golden trout include aquatic vegetation, sedges, collapsed banks, and boulders (USFWS 2011). Substrate size in suitable streams varies from coarse sand and gravels to cobbles and boulders, with channel gradients ranging from 4 to 10 percent (USFWS 2011). Cobbles and larger rocks provide cover for both juvenile and adult fish, while the gravel bottom in pool areas provides proper substrate for the excavation of nests (43 FR 15427). Little Kern golden trout also require cool, flowing, oxygenated water; adequate stream substrate; and a specific range of water temperatures to successfully reproduce (USFWS 2011). Pools in stream areas are important for Little Kern golden trout, because they are habitat for aquatic insects that are prey items for the trout (43 FR 15427).

Dispersal/Migration

Motility/Mobility

Adult: Low; home ranges (calculated as a linear distance encompassing 90 percent of locations) averaged 5 m (16 ft.) (USFWS 2011).

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low

Immigration/Emigration

Adult: Low

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: Little Kern golden trout are nonmigratory and have low rates of dispersal and immigration/emigration. Their home ranges (calculated as a linear distance encompassing 90 percent of locations) averages 5 m (16 ft.). Movements of 26 to 100 m (86 to 328 ft.) have been observed, but these constituted fewer than 1 percent of all observations. Differences in home range size may be attributed to habitat quality and population density (USFWS 2011).

Additional Life History Information

Adult: Movements of 26 to 100 m (86 to 328 ft.) have been observed, but these constituted fewer than 1 percent of all observations. Differences in home range size may be attributed to habitat quality and population density (USFWS 2011).

Population Information and Trends

Population Trends:

Varied: the populations have been sampled sporadically, and many have been variable between years. In addition, many populations were recovering from chemical treatments during the most recent sampling event, so their numbers were likely fluctuating during recovery (USFWS 2011).

Species Trends:

Long-term decline of 50 to 90 percent. Short-term trend of relative stability (less than or equal to 10 percent change) (NatureServe 2015).

Number of Populations:

Six headwater streams (USFWS, 2023)

Population Size:

~60,000 (USFWS, 2023)

Resistance to Disease:

Low

Adaptability:

Low

Additional Population-level Information:

Prior to restoration efforts, approximately 90 percent of the historical range of the Little Kern golden trout was compromised through the introduction of coastal rainbow trout (O. mykiss) for the purpose of angling, leading to highly introgressed populations. At the time of listing, the Little Kern River drainage contained fewer than 5,000 Little Kern golden trout individuals. Only those streams containing natural or artificial migration barriers were thought to contain pure Little Kern golden trout populations, and these areas were short reaches of headwater streams (USFWS 2011).

Population Narrative:

There are approximately 20 populations of Little Kern golden trout (NatureServe 2015). Prior to restoration efforts, approximately 90 percent of the historical range of the Little Kern golden trout was compromised through the introduction of coastal rainbow trout (O. mykiss) for the purpose of angling, leading to highly introgressed (hybridized) populations (USFWS 2011). Since then, populations have been sampled sporadically and the abundance of many populations has been variable between years. In addition, many populations were recovering from chemical treatments during the most recent sampling event, so their numbers were likely fluctuating during recovery (USFWS 2011). The most recent genetic evidence suggests that the least genetically compromised Little Kern golden trout populations (exhibiting between 0 and 2 percent introgression levels) exist in Upper North Fork Clicks Creek, Upper Clicks Creek, Trout Meadow Creek, Little Kern River above Broder's cabin, and Little Kern River above Wet Meadow Creek (NatureServe 2015). Only those streams containing natural or artificial migration barriers were thought to contain pure Little Kern golden trout populations, and these areas were short reaches of headwater streams (USFWS 2011).At the time of listing, the Little Kern River drainage contained fewer than 5,000 Little Kern golden trout individuals (USFWS 2011). Due to both inconsistent sampling methodology and incorrect assumptions concerning the level of hybridization, the current abundance of the Little Kern golden trout cannot be determined (USFWS 2011). However, based on occupied stream length and typical densities, the overall population likely is at least several thousand (NatureServe 2015). The trend over the past 10 years (three generations) is uncertain, but distribution and abundance have probably been relatively stable (NatureServe 2015). Distribution: Historically, the Little Kern golden trout occupied approximately 99.4 miles of streams in the Little Kern River drainage (Moyle 2002, pp. 285–286). At the time of listing in 1978, the range of pure Little Kern golden trout had been drastically reduced to only six headwater streams, totaling approximately 9.9 miles of streams, or 10% of its historical range (Christenson 1984, pp. 5, 12–13; Moyle 2002, pp. 285–286). Little Kern golden trout were translocated between creeks within their native range and to creeks (e.g., Coyote Creek) and lakes (e.g., Crites Lake and Big Five Lakes) outside of their native range beginning in the late 1800s and continuing through the late 1990s (Stephens et al. 2014, pp. 3–4, 31–32, 43; Christenson 1984, pp. 7–8, 10, 12). We did not receive any information pertaining to the current distribution of the Little Kern golden trout outside of its' native range. Beginning in 2012, the Department's Heritage and Wild Trout Program, in collaboration with the Service, Forest Service, and National Park Service began a comprehensive rangewide assessment of the subspecies and its habitat (Department 2018, entire). Little Kern golden trout of varying levels of introgression were observed in all major tributaries surveyed (see Hybridization and Low Genetic Diversity, below, for more details about introgression) (Department 2018, p. 13). Upstream distribution typically coincided with a permanent upstream barrier or lack of flow and limited habitat (Department 2018, p. 33). Based on the Department's survey results, the Little Kern golden trout occupied 23.1 miles of the Little Kern River and 62.8 miles of major tributaries, for a total of 86 miles of occupied habitat (Department 2018, pp. 14, 33). Variation in the level of introgression between populations of Little Kern golden trout and differences in survey methodology and reporting preclude accurately comparing the current distribution with historical conditions or distribution at the time of listing unless more robust meta-analyses are conducted. Abundance: Little Kern golden trout population estimates have been conducted in various years prior to and following listing by multiple practitioners using different methods making direct comparison difficult. At the time of listing, the Little Kern River drainage contained less than 5,000 pure Little Kern golden trout individuals (Christenson 1984, p. 10). Other efforts have focused on population estimates or abundance records of specific streams or stream segments, rather than rangewide assessments (Service 2011, pp. 6, 28–31). The Department conducted depletion electrofishing surveys in 21 tributaries in the Little Kern River drainage from 2012 through 2018 (Department 2018, pp. 5–6 and 15–33). In total, the Department estimated the Little Kern golden trout population contains approximately 60,000 individuals of varying levels of introgression (Department 2018, p. 34). Estimated mean abundance in occupied streams varied from a low of 31 trout/mile in No Name Creek to a high of 1,553 trout/mile in Alpine Creek (Department 2018, pp. 17–33), but variation in the level of introgression from stream to stream makes it difficult to compare subpopulation densities and estimate the mean abundance for the entire subspecies (USFWS, 2023).

Threats and Stressors

Stressor: Livestock grazing
Exposure: Livestock grazing in riparian areas.
Response: Alterations to or reductions of riparian habitat.
Consequence: Reductions in habitat quality, including less cover, higher temperatures, and sedimentation.
Narrative: Livestock grazing can have adverse impacts on stream habitat and fish populations. Cattle are attracted to riparian habitat due to the presence of water, shade, succulent vegetation, and gentle topography, and therefore riparian areas are particularly vulnerable to overgrazing. Livestock grazing can affect riparian areas by changing, reducing, or eliminating vegetation, and by the actual loss of riparian areas through channel widening, channel degradation, or lowering of the water table. Effects of fish habitat include reduction of shade and cover and resultant increases in water temperature, changes in stream morphology, and the addition of sediment due to bank degradation and offsite soil erosion. Grazing has occurred in the Little Kern River drainage for more than 100 years, initially by sheep and more recently by cattle. Both the timing and magnitude of grazing can greatly affect stream habitat conditions, adjacent riparian areas, and meadow systems with indirect effects to the Little Kern golden trout. Therefore, it is important to effectively manage grazing in terms of the number of cattle, timing of grazing, and their exclusion from streams and riparian areas, to minimize impacts to the Little Kern golden trout and its habitat. Historically, direct effects to stream habitat from grazing in the Little Kern River drainage included bank collapse and sedimentation, increasing stream width-to-depth ratios, removal of riparian vegetation, and reductions in stream pool volume. Some progress has been made on curbing the detrimental effects of grazing on the Little Kern golden trout. However, habitat conditions due to grazing and other anthropogenic impacts have not significantly changed since the time of listing in 1978; therefore, grazing continues to threaten the Little Kern golden trout (USFWS 2011).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Inadequate regulatory mechanisms.
Response: Potential inability to take action if subspecies is in danger of mortality, extirpation, or habitat loss or degradation.
Consequence: Potential mortality, extirpation, or habitat loss or degradation.

Narrative: The Endangered Species Act (ESA) is the primary federal law that provides protection for this species since its listing as threatened in 1978. Other federal and state regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the ESA. Therefore, other laws and regulations have limited ability to protect the species in the absence of the ESA (USFWS 2011).

Stressor: Introduced salmonids
Exposure: Presence of introduced salmonids.
Response: Competition
Consequence: Reduction in prey availability.
Narrative: Introductions and/or invasions of nonnative fishes are widely seen as one of the major causes of decline in a number of stream-dwelling biota, including the Little Kern golden trout. Numerous species were historically introduced into the Little Kern drainage, including the Eastern brook trout (Salvelinus fontinalis), rainbow trout (Oncorhynchus mykiss), and brown trout (Salmo trutta). Introduced populations of brook trout and rainbow trout have been greatly reduced via chemical treatments in the Little Kern drainage, and it is unlikely that brown trout occupy the drainage, due to effective fish barriers on the Little Kern River. However, chemical treatments used to eradicate these fishes ended in 1995 and more recent data on the distribution of these introduced fishes in the Little Kern River and its tributaries are not currently available. Furthermore, significant effects to the Little Kern golden trout subpopulations from rainbow trout introductions continue to persist in the drainage (i.e., introgressed Little Kern golden trout populations) (USFWS 2011).

Stressor: Hybridization and low genetic diversity
Exposure: Presence of introduced salmonids.
Response: Hybridization
Consequence: Reduction in genetic viability of subspecies.
Narrative: Nonnative rainbow trout readily hybridize with Little Kern golden trout and produce fertile offspring. Extensive genetic mixing of natives, nonnatives, and hybrids contributes to the loss of locally adapted genotypes and can lead to the extinction of a species. At the time of listing, introductions of coastal rainbow trout in the Little Kern River and its tributaries were implicated as the primary reason for this subspecies' decline. Hybridization between the introduced rainbow trout and Little Kern golden trout resulted in a reduction in pure populations and their overall range. Pure populations were thought to only persist in the uppermost headwater reaches of five tributaries to the Little Kern River, and management efforts focused on chemical eradication of introgressed populations and restocking of Little Kern golden trout between 1975 and 1996. Restoration efforts have largely been successful in removing severely introgressed populations of Little Kern golden trout and the broader influence of nonnative fishes. Little Kern golden trout populations, however, continue to show low, moderate, and even high levels of hybridization with nonnative rainbow trout. Reestablished populations of Little Kern golden trout currently exhibit significant genetic structuring typified by low levels of heterozygosity, the likely result of loss of genetic variation associated with founder effects of restocked populations. The prevalence of genetic bottlenecks and reduced gene flow suggest a further potential for reductions in genetic heterozygosity through genetic drift, likely leading to overall loss of adaptive potential. This suggests that Little Kern golden trout populations may be particularly vulnerable to stochastic events and/or changing habitat conditions associated with climate change (USFWS 2011).

Stressor: Limited range and small population sizes
Exposure: Small, isolated populations.
Response: Increased risk of inbreeding, loss of genetic diversity, and extinction due to stochastic events.
Consequence: Reduced fitness and increased extinction risk.
Narrative: The majority of extant Little Kern golden trout populations show introgression levels less than or equal to 5 percent, but moderate to highly introgressed populations continue to persist in the basin. The most genetically pure populations (between 0 and 2 percent introgression levels) are currently limited to a few populations that occur in a small proportion of the historical range of the Little Kern golden trout. In addition, because the current distribution of pure Little Kern golden trout is limited to a few small populations, these populations are vulnerable to stochastic extinction events. Ultimately, to achieve recovery, pure Little Kern golden trout should be reestablished throughout their entire historical range (i.e., the Little Kern River drainage) (USFWS 2011).

Stressor: Climate change
Exposure: Climate change.
Response: Predicted increased stream temperatures, decreased flow, changes in hydrograph, and increased numbers of extreme events.
Consequence: Potential for reduced habitat quality and quantity, as well as thermal stress.
Narrative: The impacts of climate change on the Little Kern golden trout are not known with certainty. Predicted outcomes of climate change imply that negative impacts will occur through increases in stream temperatures, decreases in stream flow, and broader changes to the stream hydrograph. The extent to which these physical factors affect Little Kern golden trout populations is difficult to ascertain, but maintaining spatially robust populations and maximizing genetic diversity should help buffer the negative effects of climate change on the Little Kern golden trout populations (USFWS 2011).

Recovery

Reclassification Criteria:
Little Kern golden trout are currently listed as threatened under the federal ESA. No reclassification criteria have been established for this species.

Delisting Criteria:
An official recovery plan has not been developed for the Little Kern golden trout. Instead, the Revised Fishery Management Plan for the Little Kern Golden Trout (Christenson 1984) has been accepted as the recovery plan. The principle objective of the management plan is to provide a program for restoring the Little Kern golden trout to a level where the subspecies can be delisted from Threatened status. However, this management plan does not include specific delisting criteria.

Recovery Actions:
- An official recovery plan has not been developed for the Little Kern golden trout. Instead, the Revised Fishery Management Plan for the Little Kern Golden Trout (Christenson 1984) has been accepted as the recovery plan. The following actions are outlined in the fishery management plan:

- Public information: Prepare and implement a public notification plan to inform the public of the purpose, progress, and status of the Management Plan, and notify them of current activities. The responsible agencies will coordinate on their activities on a yearly basis. Every opportunity will be taken to discuss the Management Plan with groups or individuals through meetings, letters, phone calls, and personal contact. Consideration will be given to the preparation of a film or other audio visual aids to promote understanding of the Plan. Annual activity reports will be prepared to document Management Plan progress (Christenson 1984).
- Restoration and maintenance of Little Kern golden trout populations: Alter streambed or construct barriers to prevent upstream fish migration to isolate Little Kern golden trout fish stocks, and facilitate restoration. Conduct periodic inventories of Little Kern golden trout populations to determine status, detect reduction in numbers, and monitor recovery of restored population. Restore the Wet Meadows Creek, Rifle Creek, the Willow Creek, Soda Springs Creek, and Fish Creek stocks. Restore of the balance of the Little Kern River drainage (Christenson 1984).
- Habitat protection: Conduct periodic surveys to detect changes in stream habitat, streamside vegetation, watershed conditions, and land uses and developments in the Critical Habitat which may be harmful to the Little Kern golden trout populations. Restore damaged habitat through streambank stabilization and raising the water tables in eroded portions of Fish Creek, Lion Creek, Grey Meadow Creek, Coffin Meadow, Round Meadow, Jug Spring, Clicks Creek, and other locations, as needed and feasible. Conduct resource monitoring programs to detect changes in stream ecosystems which could be harmful to Little Kern golden trout populations. Private lands in the Critical Habitat should be acquired if they become available, or if activities on those sites create threats to the Little Kern golden trout populations (Christenson 1984).
- Protect Little Kern golden trout populations from introduction of rainbow trout or other non-Little Kern golden trout fish species: Public education will stress the effects on the native Little Kern golden trout, loss of genetic integrity, competition, waste of past restoration efforts, and cost of correcting problems created by illegal transplants. Reduce access to make illegal introductions more difficult. Provide a protective buffer zone by conversion to Little Kern golden trout of immediately adjacent fish populations outside the Critical Habitat (Christenson 1984).
- Protect the Little Kern golden trout populations from overharvest: Conduct public education to achieve dispersal of angler use stressing the vulnerability of the Little Kern golden trout and their limited reproduction. Encourage voluntarily reduced bag limits to protect lake populations. Reduce bag limits or impose size limits. Close streams to angling. Change wilderness entry quotas. Reduce use in impacted areas by rerouting trails or prohibiting camping. Control vehicular access (Christenson 1984).
- Preservation of native western sucker (Catostomus occidentalis) populations: This species will be salvaged from populations in the Little Kern River drainage where they now occur, and will be restocked in those same habitat following chemical treatments (Christenson 1984).
- Other activities to increase knowledge of Little Kern golden trout and their habitat and improve their recovery and management: Little Kern golden trout population and habitat surveys, genetic research, reproductive biological and behavior studies, migration studies, and fecundity studies have all increased the understanding of the Little Kern golden trout resource. Further studies of the biology and ecology of the Little Kern golden trout will be

done as needs are determined and funds available (Christenson 1984).

- The Sequoia National Forest submitted the draft Environmental Analysis Report on the Management Plan to the U.S. Fish and Wildlife Service (USFWS), and the report was approved on June 24, 1983 (Christenson 1984). A summary of the requirements and constraints suggested in the final Analysis Report are listed below: 1. Finish genetic sampling and periodically sample known pure populations to ensure that they have not become contaminated. 2. Cooperating agencies prepare an annual work plan. 3. Approval of pesticide application plans by appropriate governmental agencies. 4. Prepare and implement a public information program. 5. Schedule chemical treatments to minimize impact on the public to the extent feasible. The quantity of treatments should not exceed the point that more than half the drainage cannot support fishing. 6. Chemical treatments are not to exceed the ability to restock from donor populations. 7. Salvage non-Little Kern golden trout as much as possible. 8. Retain populations of western sucker where they occur naturally. 9. Monitor effectiveness of chemical treatments. 10. Treated waters to be restocked by transplanting to speed recovery. 11. Monitor recovery of restored populations. 12. Monitor habitat, water quality, and fish population. 13. Revise Management Plan to meet Environmental Analysis and Biological Opinion requirements. 14. Initiate formal consultation if recovery problems arise. 15. Conduct sensitive plant and archaeological surveys prior to fish barrier construction (Christenson 1984).
- The USFWS reviewed the Management Plan and Environmental Analysis, and issued its Biological Opinion on April 13, 1979. The following modifications to the Plan were recommended: ?Reestablishment of stable, self-sustaining populations of Little Kern golden trout in the entire Critical Habitat area by removal of all other trout. This includes the so-called "unique trout" of the Mountaineer Creek drainage and North Fork Clicks Creek. ?Minimization of the likelihood of unauthorized fish introductions, especially rainbow trout, by any or all of the following: 1) Informing the public of all management activities to achieve understanding and cooperation, 2) Closure of streams to fishing, 3) Closure of roads and/or limitation of vehicular access to only emergency and authorized uses in the Designated Critical Habitat (Christenson 1984).
- Update the current Fishery Management Plan with a formal genetics management plan for the Little Kern River drainage, with specific actions that increase genetic diversity and restore pure populations of Little Kern golden trout throughout their entire historical range. Regularly monitor Little Kern golden trout population trends throughout the drainage, as guided by the most recent genetic information. If Little Kern golden trout hatchery programs are reinitiated, ensure that facilities are entirely separated from rainbow trout production programs (USFWS 2011).
- Initiate a systematic habitat monitoring program in the Little Kern drainage that regularly (every 5 years) assesses stream conditions throughout the drainage, including both abiotic (temperature, water quality, bank stabilization, sediment distribution, riparian vegetation recruitment, etc.) and biotic (macroinvertebrate surveys and Little Kern golden trout population surveys) factors. More sensitive stream sites, such as those in the Little Kern and Jordan grazing allotments, should be monitored more regularly (every 2 years) (USFWS 2011).
- Install and regularly maintain riparian fencing on streams in the Little Kern and Jordan grazing allotments, especially those in low-gradient meadow reaches such as Lion, Grey, and Loggy meadows (USFWS 2011).

- Regularly evaluate the structural integrity of stream barriers and their ability to inhibit the dispersal of nonnative salmonids throughout the Little Kern River drainage (especially during high water years), and make improvements where necessary. Assess the benefits of barriers in terms of preventing nonnative salmonid dispersal, and compare with the potential genetic costs of these barriers in terms of reducing gene flow between naturally occurring populations of Little Kern golden trout (USFWS 2011).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: Here we propose several habitat conservation and ecological research recommendations which will aid in the recovery and conservation of the Little Kern golden trout. Some of these recommendations have already been discussed in previous recovery documents (Service 2011, p. 22) and remain valid. 1. Update the current Fishery Management Plan to include an official genetic management plan to guide restoration actions that consider lack of genetic diversity in the population and restore pure populations of Little Kern golden trout throughout their entire historical range. A genetic management plan should incorporate the best available information from recent genetic analyses (e.g., Stephens 2014, entire; Department 2020, entire) to identify genetic management units and guide potential translocations, fish rescue, and genetic rescue efforts. 2. Conduct long-term monitoring by regularly surveying Little Kern golden trout populations and performing genetic analyses to evaluate trends in population dynamics. Consider using eDNA metabarcoding as a monitoring tool. Continue and expand systematic habitat monitoring in the Little Kern drainage that regularly (every five years) assesses stream conditions throughout the drainage, including both abiotic (temperature, water quality, bank stabilization, sediment distribution, riparian vegetation recruitment, etc.) and biotic (macroinvertebrate surveys and Little Kern golden trout population surveys) factors. More sensitive stream sites, such as those located in the Little Kern and Jordan grazing allotments or drainages that have recently been impacted by fire should be monitored more regularly (every two years). 3. Regularly evaluate the structural integrity of stream barriers and their ability to inhibit the dispersal of non-native salmonids throughout the Little Kern River drainage (especially during high water years) and make improvements where necessary. Assess and weigh the impacts of barriers (e.g., preventing further hybridization and competition with nonnative salmonids, reduction of gene flow between Little Kern golden trout populations, increased inbreeding). Consider these factors when deciding if improvements to existing barriers or construction of new barriers is necessary for the conservation of Little Kern golden trout populations. Consider experimental barrier removal to improve Little Kern golden trout dispersal and prevent further population bottlenecking. 4. Investigate the cause and impact of fin erosion on Little Kern golden trout and identify and implement corrective actions, if necessary. 5. In order to reflect the most current understanding of the subspecies' taxonomy, formally change the species name in the Code of Federal Regulations from Oncorhynchus aguabonita whitei to Oncorhynchus mykiss whitei (USFWS, 2023).

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SPECIES ACCOUNT: *Oncorhynchus clarki stomias* (Greenback Cutthroat trout)

Species Taxonomic and Listing Information

Listing Status: Threatened; 03/11/1967; Mountain-Prairie Region (R6)

Physical Description

A fish (cutthroat trout) 38 cm long. Differs from the Colorado River cutthroat trout in tending to have larger spots and more scales (typically more than 45 scales above the lateral line and more than 185 in the lateral series); does not have any more green on the back than does any other subspecies of cutthroat trout (Behnke 1992) (NatureServe, 2015).

Taxonomy

The greenback cutthroat trout, (Oncorhynchus clarki stomias, formerly Salmo clarki stomias), is one of the most colorful subspecies of cutthroats (USFWS, 1998).

Historical Range

Historically occurred in the sources of the South Platte River and Arkansas River in Colorado, from the headwaters to the foothills, and in a few headwater tributaries of the South Platte in a small area of southeastern Wyoming (Behnke 1992) (NatureServe, 2015).

Current Range

Currently, in the South Platte drainage, most stable populations are in Rocky Mountain National Park; a few stable populations exist in the Arkansas River drainage (Young and Harig 2001) (NatureServe, 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Adults and immatures are invertivores; eats aquatic insects (NatureServe, 2015). Adults requires fast water areas for feeding. Greenbacks are opportunistic feeders over a wide range of prey organisms, but a large percentage of the diet can be terrestrial insects (McGrath 2004) (USFWS, 2009).

Reproduction Narrative

Adult: Spawns in riffles in spring or, in some high-elevation sites, early summer (NatureServe, 2015). Spawning adults require clean gravels (USFWS, 2009). Spawning is generally initiated in the spring when water temperatures reach 5oC-8oC. Although Como Creek greenbacks can produce eggs at age 2 in the hatchery, females in small subalpine streams within Colorado appear to mature after their third to fourth summer of life when they reach lengths of approximately 180 mm. Como Creek greenbacks (Type A) held at the USFWS Fish Technology Center (FTC) at Bozeman, Montana, produced 1.5 eggs per gram of female weight for 2-year-old greenbacks weighing 254 grams, and 1.4 eggs per gram of female weight for 3-year-olds weighing 357 grams (Dwyer 1981) (USFWS, 1998).

Geographic or Habitat Restraints or Barriers

Adult: Occurs ~9,327 ft. elevation (USFWS, 2009)

Environmental Specificity

Adult: Narrow (inferred from USFWS, 2009)

Habitat Narrative

Adult: Clear, swift-flowing mountain streams with cover such as overhanging banks and vegetation; juveniles tend to shelter in shallow backwaters; also in lakes (Matthews and Moseley 1990) (NatureServe, 2015). In general, trout require different habitat types for different life stages: juvenile (protective cover and low velocity flow, as in side channels and small tributaries); over-winter (deep water with low velocity flow and protective cover); and adult (juxtaposition of slow water areas for resting and fast water areas for feeding, with protective cover from boulders, logs, overhanging vegetation or undercut banks) (Behnke 1992). Greenbacks, like other cutthroat trout, generally require clear, cold, well oxygenated water (McGrath 2004). Most occupied greenback streams are at high elevation (average 9,327 ft.) and relatively small in size (USFWS, 2009).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Not available

Population Information and Trends

Population Trends:

Not available

Species Trends:

> 10% increase (NatureServe, 2015)

Number of Populations:

145 (USFWS, 2009)

Population Narrative:

Only five naturally occurring pure populations are known to have survived into recent times; brood stocks were developed from these sources, and subsequent introductions established many populations in 12 streams (81 km) and five lakes (44 ha) by 1987; new introductions have occurred since then (Behnke 1992). The population has increased (> 10%) in recent decades due to successful reintroduction efforts. As of 1999, 21 of 55 populations were considered to be stable, and more than half of these were within Rocky Mountain National Park (Young and Harig 2001) (NatureServe, 2015). The Inland Cutthroat Trout range-wide protocol (Western Native Trout Initiative (WNTI) 2007) documented 145 populations, considered to be Type A at the time

(USFWS, 2009).

Threats and Stressors

Stressor: Mining (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Early mining and ore processing activities produced waste piles and mine tailings that contained heavy metals and acid-generating compounds. These piles were, and in many cases continue to be, leached by flowing water, resulting in increased acidity, decreased pH, and heavy metal concentrations downstream. Water draining from historic mine tunnels and adits (horizontal passages leading into mines) also may contain high concentrations of heavy metals and be characterized by a low pH value (acidic). Larval greenbacks have been shown to be more sensitive to low pH than eggs and embryos, with a pH of 5 being a threshold for larvae in the absence of aluminum (WNTI 2007). Such pollution can negatively affect fishes through asphyxiation, ecological impacts due to destruction of food organisms, chronic toxicity resulting in reduced resistance to infection and other stresses, and interference with behavioral patterns. In addition, some waters within the range of greenbacks are impacted by naturally high levels of heavy metals. Today, mining activities are not as prevalent and are under environmental permitting and reclamation restrictions that minimize polluted runoff from mine sites (USFWS, 2009).

Stressor: Land use activities (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Several types of activities may negatively impact greenback habitat through removal of riparian habitat which shades streams and lowers water temperatures, and through vegetation removal and trampling of streambanks, which cause bank erosion, producing stream sedimentation. Logging, grazing, road and trail construction and use, and recreational vehicle use near streams have the potential to cause a negative chain reaction by contributing to bank destabilization, which causes an increase in erosion, sediment deposition, and in turn a threat of elevated water temperatures and higher turbidity in lower elevation habitats. In addition to the direct effects of vegetation removal and trampling, these types of land management activities also can reduce the input of terrestrial insects, which comprise about half of the diet of trout populations, into the aquatic environment (Saunders and Fausch 2007) (USFWS, 2009).

Stressor: Fire management activities (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Fire is a natural component of the ecological region occupied by the greenback; however, fire suppression over the past 80 to 100 years in North America has resulted in many forest types with substantial fuel accumulations that are at risk of wildfires that burn at a greater intensity and severity than historically occurred. The added effects of drought, climate change, and large acreages of recently beetle-killed timber add to the potential fire risk (Thompson pers. comm. 2008; Watry pers. comm. 2008). While managers do their best to control and or prevent

fire, unplanned fires, such as the 2002 Hayman fire, do occur and can have negative impacts on aquatic species and their habitat. The direct effects of fire can be severe to fish both from the increases in stream temperature, and from smoke and ash (both immediate ashfall and later erosional deposition) that can cause an increase in ammonia and respiratory distress, respectively. Indirect adverse effects can result from the loss of streamside and forest vegetation and include erosion and loss of bank stabilization from burned vegetation cover and bankside vegetation, which increases sediment, causing increased turbidity, and increasing stream temperature. Chemical fire-fighting retardants are known to be toxic to aquatic wildlife and lethal levels have been documented in studies on rainbow trout (Buhl and Hamilton 2000). An additional threat to greenback populations from fire management is the potential to introduce whirling disease into greenback streams by the aerial application of water during fire-fighting activities (USFWS, 2009).

Stressor: Water depletions and water storage facilities (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Water management, movement and storage have occurred within the range of the greenback since the 1880s, and continue to the present day. Even within RMNP, water is diverted from the Colorado River drainage into the South Platte drainage (Poudre River), and dams were constructed prior to the creation of the RMNP in 1915. Continued rapid development is expected along Colorado's East slope as the human population continues to grow. In theory, demand for water within the range of greenback habitat is expected to increase commensurate with population growth. Potential water diversions or depletions can reduce stream flow, fragment stream habitat, restrict greenback movement along stream corridors, and adversely impact water quality, aquatic food chains, and watershed conditions (USFWS, 2009).

Stressor: Whirling disease (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Whirling disease is a parasitic infection caused by Myxobolus cerebralis that impacts young trout, and can infect the greenback. Parasites enter through the nerve endings on the skin, and feed upon cartilage in the head and spinal area of young fish, resulting in pressure on the nerves and equilibrium loss (Whirling Disease Foundation 2009). The disease can be spread through hatcheries use and/or release of contaminated water, stocking of infected fish, by mud on angler equipment, and by birds eating infected fish. Since greenback populations exist in relatively unaltered habitats, and many of the higher/colder elevation streams have low numbers of the required intermediate host, whirling disease does not appear to be a high threat to current populations. However, the presence of the disease may limit future reproduction and reintroduction of all salmonids in lower elevation lakes and streams (USFWS, 2009).

Stressor: Nonnative salmonid species (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: The number one reason for the historic decline of the greenback was the introduction of nonnative salmonid fish species (Behnke 1992). Nonnative fish species pose a threat to the

greenback for several reasons. The greenback hybridizes with several introduced fish species, such as the rainbow trout, while other species like the brook trout are competitors. Both of these species also prey on young greenbacks. Brown trout prey on all sizes of greenback. Brook trout (a fall-spawning, cold hardy char) apparently outcompete the greenback for common food sources early in life in most stream habitats (USFWS, 2009).

Stressor: New Zealand mud snail (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: The New Zealand mud snail (NZMS) is a recently introduced species that has the potential to negatively impact the greenback. The NZMS could displace native invertebrates which provide food for cutthroat trout. Five species of mollusks (all native to the Snake River) have recently been listed as "endangered" in part due to the establishment of the NZMS and its potential impacts. Establishment is expected to have negative impacts on native fauna (e.g., decrease in densities of herbivorous invertebrates, decrease in attached filter-feeding organisms). This species may have the potential to impact the food chain of native trout and other fish species and have the potential to disrupt the physical characteristics of invaded ecosystems (e.g., reduction in the biomass of periphyton and the resulting interactions can have wide-ranging effects on stream ecosystem processes) (Aquatic Nuisance Species Task Force 2008).

Stressor: Zebra and quagga mussels (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Quagga and zebra mussels smother aquatic organisms, such as crayfish and native clams and outcompete other aquatic organisms for food and aquatic habitat. The extent of their potential impacts on greenback populations, should they spread into inhabited streams, is unknown (USFWS, 2009).

Stressor: Contaminants (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: From 2002 to 2007, researchers conducted analysis of the concentrations and biological effects of airborne contaminants in air, snow, water, sediments, lichens, pine needles, and fish in eight national parks, including RMNP. The study found high levels of endosulfans and dacthal in snowpack depositions and also in fish samples in RMNP. Mercury levels in fish samples were fairly low, although mercury level increased with increasing age of fish. Poorly developed testes and or intersex trout were found in five of the nine lakes tested in RMNP, indicating that endocrine and reproductive disruption is occurring (Landers et al. 2008) (USFWS, 2009).

Stressor: Climate change (USFWS, 2009)
Exposure:
Response:
Consequence:

Narrative: Recent studies have indicated that global warming has the potential to adversely affect river systems that support greenback (Defenders of Wildlife 2002; Ficke et al. 2007). In general, threats from climate change could affect fish populations through reduction of precipitation, increase in fire, and increase in stream temperature. Higher temperatures in lentic systems (lakes) also could increase evaporation and result in lowered lake levels (Ficke et al. 2007) (USFWS, 2009).

Stressor: Fragmentation (USFWS, 2009)
Exposure:
Response:
Consequence:
Narrative: Barriers contribute to isolation, restricting gene flow, and have the potential of genetic bottlenecking unless managers move small numbers of fish between the populations. More than 90% of the stream segments occupied by greenback are less than 5 km in length, with an average length of 2.37 km (Albeke 2008). Small, isolated populations also are vulnerable to stochastic events, such as drought, flooding, and fires (USFWS, 2009).

Recovery

Delisting Criteria:
1. Maintain or enhance all known Type A greenback populations (USFWS, 2009).

2. Establish or document the existence of 20 stable populations of pure (Type A) greenback within the subspecies' historic range (USFWS, 2009).

3. Establish hatchery and wild populations of pure (Type A) greenback broodstock (USFWS, 2009).

4. Document response to angler pressure, stocking rates, fish diseases, fishing regulations, and native non-salmonids (USFWS, 2009).

5. Conduct an information and education program (USFWS, 2009).

6. Promote partnerships with conservation groups and explore alternative management and funding strategies (USFWS, 2009).

7. Prepare a long-term management plan and cooperative management agreement for the greenback (USFWS, 2009).

Recovery Actions:
- Maintain existing populations of greenbacks (USFWS, 1998).
- Establish or document, 20 stable populations of greenbacks (USFWS, 1998).
- Establish captive and wild greenback broodstocks within Colorado (USFWS, 1998).
- Conduct research on greenback angling programs and hatchery programs (USFWS, 1998).
- Conduct greenback information and education programs (USFWS, 1998).
- Promote partnerships, and expand efforts to obtain non-agency funding (USFWS, 1998).

- Prepare a long-term greenback management plan and cooperative agreement (USFWS, 1998).
- The Recovery Team, in coordination with the Service, should make a determination of the taxonomic distinctions between greenback and Colorado River cutthroat trout. This “subspecies” definition should take into account morphometric and meristic characteristics, genetics, and current Service policy and legal decisions. Recommendations of an expert panel or additional peer review of available genetic information should be used to help with this determination, and the results should be published in a peer-reviewed journal (USFWS, 2009).
- The Recovery Team, in coordination with the Service, should continue to promote and fund research that will help to delineate the genetic make-up of populations of both (presumed) greenback and Colorado River cutthroat trout, to aid in the taxonomic review (USFWS, 2009).
- Given the significant amount of new information that has been acquired on both threats and genetics since 1998, the Recovery Team should update and revise the Recovery Plan, including the identification of measurable recovery goals for all Objectives. Principles of Strategic Habitat Conservation, such as identification of limiting factors and development of population-habitat relationship models, should be used to formulate habitat objectives and design a conservation plan for the subspecies (USFWS, 2009).
- Development of a long-term management plan for a recovered population should be initiated upon completion of the revised plan. This plan should address the requirements of section 4(g) of the ESA and comply with our 2008 post-delisting monitoring guidance (USFWS 2008) (USFWS, 2009).
- The Recovery Team should identify those historic native populations whose genetic material is currently not replicated, either in a stream or fish hatchery, and should replicate the population (USFWS, 2009).
- The Recovery Team should work collectively to establish and implement standardized population and habitat monitoring protocols for the subspecies (USFWS, 2009).
- The Recovery Team should explore feasible ways to connect isolated populations (develop metapopulations) wherever possible, while still preserving viable small populations that are dispersed throughout the range of the subspecies, to buffer against catastrophic loss of large, interconnected populations. As a contingency, the Recovery Team also should develop a plan for supplementing isolated populations to ensure genetic robustness, or to re-populate areas that become extirpated due to stochastic events (USFWS, 2009).
- The Recovery Team, and the agencies and organizations involved, should continue to use creative funding mechanisms for implementing recovery actions, such as the Western Native Trout Initiative (USFWS, 2009).
- The regulatory and land management agencies involved with greenback recovery should continue their efforts to improve habitat conditions, to establish new populations as appropriate, and minimize the negative effects of ongoing and proposed actions on the subspecies (USFWS, 2009).
- Needs of the greenback must continue to be considered when planning fire management activities, through the development of contingency plans and conservation measures to proactively prepare for the threat of fire (USFWS, 2009).
- Data and information about climate change should continue to be obtained and analyzed to determine how greenback might be affected (USFWS, 2009).

- Land management agencies and hatchery operators must continue to implement preventative mechanisms in hatcheries and in fish stocking operations to prevent the spread of whirling disease (USFWS, 2009).
- Populations used for broodstocks should continue to be monitored for fish diseases, and greenback populations should be sampled as part of the Service's wild fish health monitoring (USFWS, 2009).
- Plans should be developed and implemented to preclude the spread of non-desirable organisms into greenback habitat. Contingency plans also should be developed for use in the event that occupied greenback habitat is colonized by a new disease, competitor, or predatory species (USFWS, 2009).
- Current management strategies, including the eradication of nonnatives at relocation and translocation sites, need to be continued to prevent competition from nonnative species. Measures to eradicate nonnative species, such as mechanical barriers and/or lethal chemicals, should be evaluated for the 25% of the range where greenbacks co-occur with nonnative salmonids. Other innovative ways to protect the greenback from nonnative species should be considered to prevent population isolation caused by natural and non-natural barriers (USFWS, 2009).

Conservation Measures and Best Management Practices:

- We have identified the following ongoing research studies aimed at improving our knowledge and understanding of the ecology of the GBCT, ultimately leading to improved conservation and recovery: a) Comparison of extant population in Bear Creek to museum specimens to determine if they are morphologically similar to what was in the South Platte basin historically. This study could influence future discussions on population supplementation (by other subspecies) if necessary (ongoing). b) Evaluation of genetic diversity in Bear Creek fish relative to museum specimens using whole-genome sequencing technology. This study could influence future discussions on population supplementation (by other subspecies) if necessary (ongoing). c) Evaluation of fitness of developing broodstocks with both lab and field based studies to determine viability of reintroduction stock (ongoing). d) Conduct stocking in lower elevation habitats to provide for comparative studies of reproduction, fecundity, and survival over a wider range of conditions to help delineate the key attributes of optimal GBCT habitat (ongoing). e) Synthesize inventory and monitoring information to understand "thresholds", limiting factors and key characteristics for restoration success (ongoing). f) Investigate diversity in existing broodstock and develop a strategy to maintain and increase heterozygosity in hatchery populations (ongoing). g) Monitor incidence of deformities in Zimmerman Lake and hatchery-reared GBCT (ongoing). (USFWS, 2019)

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SPECIES ACCOUNT: *Oncorhynchus clarkii henshawi* (Lahontan cutthroat trout)

Species Taxonomic and Listing Information

Listing Status: Threatened; originally listed as Endangered on October 13, 1970 (35 FR 16047) under the Endangered Species Conservation Act of 1969; downlisted to Threatened in July 16, 1975 (40 FR 29864) under the Endangered Species Act of 1973 to facilitate management and allow regulated angling (USFWS 1995; USFWS 2009).

Physical Description

The Lahontan cutthroat trout is an inland subspecies, and the largest subspecies of cutthroat trout. Lahontan cutthroat trout are steel gray to olive green above, with yellow-brown sides and red or pink along the belly. Round black spots are scattered over fish, but are more closely grouped toward the tail. Fins are uniform in color. Fish in smaller streams do not show the distinct color change, and tend to be olive and yellowish on the back and sides. Larger lake-dwelling Lahontan cutthroat trout tend to have copper-colored sides. The crimson red or orange slash marks on throat under the jaw that give this fish its name are usually present to some degree, but yellow variations occur. At maturity, the Lahontan cutthroat trout average 20 to 23 centimeters (cm) (8 to 9 inches [in.]) in length in small streams, and 20 to 56 cm (8 to 22 in.) in length in larger rivers and lakes. In ideal environments, the Lahontan cutthroat trout attains typical weights of 0.11 to 3.63 kilogram (kg) (0.25 to 8 pounds [lb]). The world record cutthroat trout is a Lahontan cutthroat trout, which measured 99 cm (39 in.) and weighed 19 kg (41 lb.). Adfluvial Lahontan cutthroat trout historically grew to 61 to 122 cm (2 to 4 feet) in length in Pyramid and Walker lakes (USFWS 1995; USFWS 2009; USFWS 2013).

Taxonomy

Lahontan cutthroat trout was first listed as Salmo clarki henshawi; however, all western North American trout have been reclassified from the genus Salmo to the genus Oncorhynchus. More recently, the species name for all cutthroat trout changed from clarki to clarkii to reflect the original spelling (USFWS 2009). There are three physical characteristics separating Lahontan cutthroat trout from other subspecies of cutthroat trout: 1) the pattern of medium-large, rounded spots, somewhat evenly distributed over the sides of the body, on the head, and often on the abdomen; 2) the highest number of gillrakers found in any trout—21 to 28, with mean values ranging from 23 to 26; and 3) a high number of pyloric caeca (fingerlike projections near the junction of the stomach and the intestines that secrete digestive enzymes)—40 to 75 or more, with mean values of more than 50. Variability in these characteristics forms a basis for designation of different subspecies of cutthroat trout in basins of the western United States. Chromosome karyotyping and protein electrophoresis increases discrimination between various populations of cutthroat over that provided by morphology, but also provides a definitive means of identifying rainbow-cutthroat trout hybridization, which is not always possible using morphological characteristics that can be influenced by environmental effects. Although the Lahontan basin cutthroat trout populations are genetically similar, subtle differences among populations in different subbasins have been detected (USFWS 1995; USFWS 2009).

Historical Range

Lahontan cutthroat trout (LCT; Oncorhynchus clarkii henshawi) evolved within the geographically isolated Lahontan Basin, which historically contained a large Pleistocene-era lake known as Lake Lahontan. This lake ebbed and flowed for several million years, reaching its high stand approximately 650 thousand years before present and covered most of northwestern Nevada at that time (Reheis et al. 2002). Starting about 13,500 years ago, ancient Lake Lahontan began to desiccate, decreasing in elevation due to a warming trend in this region that is still continuing today (Thompson et al. 1986; Benson & Thompson 1987). The large and interconnected ancient lake system became fragmented over time, resulting in a network of lakes and sinks within the basin fed by river and/or stream systems. LCT developed several life-history strategies and characteristics over this time to adapt to differences in the available stream, river, and/or lake habitats. In addition, some drainage basins became isolated, resulting in genetic and/or morphological differentiation of LCT populations over time. In 1800, it is believed that over 370,000 surface acres of lake (in 12 larger lake systems) and more than 7,400 miles of stream/river habitat was occupied or had the potential to be occupied by LCT (Gerstung 1986, US Fish and Wildlife Service (USFWS) 2009). However, starting in the mid 1800's, significant changes occurred across the landscape as settlement of the Lahontan Basin and northern California began. Over harvesting of LCT, mining, logging, pollution, water diversions, dams and reservoirs, and introduction of non-native trout species significantly reduced the amount and quality of habitat available and numbers of LCT. By the early 1900's, noticeable reductions in LCT numbers and populations had occurred (USFWS 1995); by the mid 1900's, LCT were extirpated from a majority of major drainage basins, and generally restricted to isolated headwater or small lake systems. The historical range of LCT is entirely within the Lahontan hydrographic basin (Figure 1), with the exception of Thousand-Virgin and the Alvord Lake subbasins, which were historically occupied by an evolutionarily-similar lineage of inland cutthroat trout, the Alvord cutthroat trout.

Current Range

LCT is documented to occur throughout its historical range with the exception of the Susan River basin. It is unknown when LCT were extirpated from the Susan River basin. Among the documented occurrences, 72 self-sustaining LCT populations currently exist in approximately 10.5 percent of historical habitat (752 stream miles and 1,394 surface acres); however, the majority of the existing populations are in smaller, isolated habitat fragments and/or have lower abundances due to poor habitat quality, and are likely not resilient in the long-term. Within the historical range of LCT, approximately 68.3 percent of historical stream and lake habitat (7,457 miles and 372,330 surface acres, respectively) are potentially suitable habitat for LCT today, including currently occupied habitats. This loss is due to climatic and anthropogenic factors over the last several hundred years that have resulted in either the complete loss of habitat or increased temperatures within habitats at lower elevations. Because of this reduction in habitat suitability across the historical range over time, self-sustaining LCT populations currently occupy approximately 15 percent of the potentially suitable habitat (see Updated Objectives for more information).

Distinct Population Segments Defined

No.

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Stream-resident Lahontan cutthroat trout are opportunistic feeders, with diets consisting of drift organisms, typically terrestrial and aquatic insects. In lakes, small Lahontan cutthroat trout feed largely on insects and zooplankton, and larger Lahontan cutthroat trout become piscivorous (USFWS 2009). In Pyramid Lake, fish enter the diet when Lahontan cutthroat trout reach 20 cm (7.9 in.) in length, represent more than 50 percent of their diet at 30 cm (11.8 in.) in length, and almost 100 percent of their diet when they have grown to 50 cm (19.7 in.) or more (USFWS 1995).

Reproduction Narrative

Adult: Lahontan cutthroat trout inhabit lakes and streams but are obligatory stream spawners. Small, intermittent, tributary streams and headwater reaches with riffles and well-washed gravels are sometimes used as spawning sites. Spawning generally occurs from April through July, depending on stream flow, elevation, and water temperature. Fecundity of 600 to 8,000 eggs per female has been reported for lake-dwelling populations, while only 100 to 300 eggs were found in females collected from small Nevada streams. More than 60 percent of male and female Lahontan cutthroat die after their first time spawning, and those that remain usually spawn again after 2 years or more. Consecutive repeat spawning is very rare. Eggs are deposited in small gravels in riffles or pool crests. Eggs generally hatch within 4 to 6 weeks, depending on water temperature; fry emerge 13 to 23 days later (USFWS 1995; USFWS 2009; 73 FR 52257).

Geographic or Habitat Restraints or Barriers

Adult: Water diversions, dams, levees, reservoirs, and channelization (USFWS 2009).

Spatial Arrangements of the Population

Adult: Uniform

Environmental Specificity

Adult: Community with key requirements common.

Tolerance Ranges/Thresholds

Adult: Moderate

Site Fidelity

Adult: Moderate

Dependency on Other Individuals or Species for Habitat

Adult: None

Habitat Narrative

Adult: Lahontan cutthroat trout inhabit cold, fresh water and alkaline lakes; small fresh water mountain lakes and streams; small tributary streams; and major rivers of the Lahontan Basin (USFWS 2009; NatureServe 2015). They use deep and shallow lake habitat and high to moderate gradient riverine habitat (NatureServe 2015). Spawning occurs in cool-water streams, generally in riffle areas over gravel substrate. Spawning and nursery habitat is characterized by cool water, well-vegetated and stable stream banks, approximately 1:1 pool-riffle ratio, and relatively silt-free rocky substrate in riffle-run areas (USFWS 1995). Water diversions, dams, levees, reservoirs, and channelization create barriers to the habitat range for Lahontan cutthroat trout (USFWS 2009).

Dispersal/Migration

Motility/Mobility

Adult: Moderate due to physical barriers.

Migratory vs Non-migratory vs Seasonal Movements

Adult: Migratory/in spring to summer.

Dispersal

Adult: Moderate

Immigration/Emigration

Adult: Unlikely due to physical barriers; stocking of areas outside of usual habitat with hatchery stocks of Lahontan cutthroat trout occurs for sport fishing (USFWS 2009).

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: Lahontan cutthroat trout migrate from their rearing habitat to spawning habitat from spring to late summer. Sufficient cool water flows are needed for upstream migration. Physical barriers prevent migration to the majority of their historic spawning habitat. Stocking of areas outside the current habitat occurs with hatchery stocks of Lahontan cutthroat trout for sport fishing (USFWS 1995; USFWS 2009; USFWS 2013; NatureServe 2015).

Population Information and Trends

Population Trends:

Decreasing

Species Trends:

Decreasing

Resiliency:

Low

Representation:

Low

Redundancy:

Low

Number of Populations:

72

Population Size:
Unknown

Minimum Viable Population Size:
2,500

Resistance to Disease:
High

Adaptability:
Moderate

Population Narrative:
Lahontan cutthroat trout populations fluctuate significantly because of highly variable environmental conditions in the Great Basin and life history attributes of the subspecies. Extensive demographic studies of Lahontan cutthroat trout indicate extreme year-to-year variability in numbers of each age class. This variability in numbers reflects variability in recruitment and survival among years. Data from several populations indicate that recruitment is strongly associated with average stream flow from March through June, and that survival is a strong function of population density. Seasonal and annual changes in climatic conditions and stream discharge can lead to dramatic population expansions or contractions. Despite the high variability found in population size, a general decline in population size was observed in 13 different streams studied in the Eastern Lahontan Basin from 1996 to 2002 (USFWS 2009).

Threats and Stressors

Stressor: Nonnative fish
Exposure: Nonnative fish introduced to Lahontan cutthroat trout aquatic habitat.
Response: Reduced growth; loss of genetic distinction.
Consequence: Reduced populations; species extinction.
Narrative: Nonnative fish, especially salmonid species, are currently the greatest threat to Lahontan cutthroat trout range-wide, resulting in loss of available habitat and range constrictions, primarily through competition and hybridization. Hybridization can lead to extinction of Lahontan cutthroat trout species through loss of genetic identity (USFWS 2009).

Stressor: Population isolation and fragmentation
Exposure: Barriers to movement in streams; reduction in lake water levels; stochastic events.
Response: Loss of genetic diversity; reduced population fitness.
Consequence: Reduced populations; extinction.
Narrative: Habitat fragmentation causes declines in the Lahontan cutthroat trout population. Habitat fragmentation reduces the total habitat available, reduces habitat complexity, and prevents gene flow. Fragmentation accelerates extinction, especially when movement of fish among stream segments is not possible, which is the case with the majority of Lahontan cutthroat trout populations. Isolated populations are vulnerable to extinction through demographic stochasticity (random fluctuations in birth and death rates); environmental stochasticity (random variation in environmental attributes) and catastrophes; loss of genetic heterozygosity (genetic diversity) and rare alleles (inherited forms of a genetic trait); and human

disturbance. Completely isolated populations are the most severe form of fragmentation, because gene flow among populations does not occur, thereby inflicting inbreeding depression dynamics on the population and reducing fitness. Evidence of loss of genetic diversity has been found in small, isolated Lahontan cutthroat trout populations; while large connected populations have higher genetic diversity (USFWS 2009).

Stressor: Land use activities
Exposure: Runoff into aquatic habitat.
Response: Reduced growth.
Consequence: Reduced populations.
Narrative: Land use activities—such as grazing, stream de-watering, mining, hydroelectric facilities, timber harvest, and roads—can negatively impact aquatic systems through sedimentation, nutrient enrichment, contaminants, altered hydrology, loss of large woody debris, and loss of riparian and stream habitat, leading to reduced growth and loss of population fitness (USFWS 2009).

Stressor: Habitat condition
Exposure: Drought and fire.
Response: Reduced growth.
Consequence: Reduced populations.
Narrative: Drought and fire related effects can impact fish due to loss of habitat, poor water quality (i.e., hypoxia and temperature), decreased ability for movement, crowding, or desiccation (USFWS 2009).

Stressor: Water quality
Exposure: Drought and water diversion.
Response: Reduced growth.
Consequence: Reduced populations.
Narrative: Terminal lakes, such as Pyramid and Walker lakes, are sensitive to changes in stream inflows. Dams on tributaries of the Truckee River have significant impacts on Truckee River discharge. Lake levels have fluctuated over time due to natural and anthropogenic influences. Lower lake levels cause water quality issues, including lowered dissolved oxygen, increased nutrient concentrations, increased temperatures, increased concentrations of pollutants from upstream urban areas, and increased total dissolved solids (USFWS 2009).

Recovery

Reclassification Criteria:
Three DPSs of Lahontan cutthroat trout were discussed in the species' Recovery Plan. However, these DPSs were not listed through a formal rule-making process (USFWS 1995; USFWS 2009). The Recovery Plan was updated in 2019 (LCT CC 2019) to refeclt current management and complete recovery objectives for the entire historical range. The historical range was divided into 10 Management Units, each with it owns recovery objectives. There is no reclassification criteria, only delisting criteria

Delisting Criteria:
LCT will be considerd for delisting when each of the 10 Management Units meets its recovery objectives. When the updated objectives are accomplished, a total of at least 40 resilient LCT

recovery populations will be present across the species historical range. This will include: • At least 6 lacustrine LCT recovery populations present within 5 of the 10 LCT Management Units, several of which are in known climate-resilient habitats; and • At least 34 fluvial recovery populations present within 7 of the 10 LCT Units, with each unit containing at least 1 population that displays meta-population dynamics; and • Meta-population dynamics present within at least 15 recovery populations spread throughout LCT's historical range.

Recovery Actions:

- In order to recovery LCT, we need to meaningfully manage its two greatest threats, non-native trout and habitat loss, degradation, and fragmentation. Thus, the management of non-native trout and the improvement of habitat condidtions in areas critical for LCT recovery must occur to delist.

Conservation Measures and Best Management Practices:

- Transplants;
- Extensive population survey and habitat inventory;
- Genetic evaluation;
- Habitat improvement activities;
- Changes in grazing practices;
- Riparian fencing and exclosures;
- Land exchanges to secure important habitat;
- Fishing regulation and season closures; and
- Fishery management plans for several basins and subbasins.
- Manage Non-native Trout
- Improve Habitat Conditions

Additional Threshold Information:

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SPECIES ACCOUNT: *Oncorhynchus clarkii seleniris* (Paiute cutthroat trout)

Species Taxonomic and Listing Information

Commonly-used Acronym: PCT

Listing Status: Endangered; March 11, 1967 (32 FR 4001). Downlisted to Threatened; July 16, 1975 (40 FR 29863). A special rule under ESA section 4(d) was published in conjunction with the downlisting rule to facilitate management by the State of California and allow State-permitted sport harvest (Service 1975).

Physical Description

The Paiute cutthroat trout (Oncorhynchus clarkii seleniris; PCT) is a distinctive member of the cutthroat trout complex, distinguishable from other cutthroat trouts by body coloration and the absence, or near absence, of body spots. Other distinguishing characteristics include a slender body form, relatively small scales, and vivid coloration (USFWS 2004).

Taxonomy

Cutthroat trout (Oncorhynchus clarkii) have the most extensive range of any inland trout species of western North America, and occur in anadromous, nonanadromous, fluvial, and lacustrine populations. Differentiation of the species into 14 recognized subspecies occurred during subsequent general desiccation and isolation of the Great Basin and Intermountain Regions since the end of the Pleistocene. The cutthroat trout was present in most of their historical range prior to the last major Pleistocene glacial advance (USFWS 2013). Based on comparison of gillrakers, it was determined that the separation of Paiute cutthroat from Lahontan cutthroat (O. c. henshawi) occurred relatively recently (no more than 5,000 to 8,000 years ago), following desiccation of Lake Lahontan. Investigations of population genetic structure of the Lahontan group of cutthroat trout detected no unique alleles in PCT; however, microsatellite allelic frequency data indicated considerable genetic differentiation from Lahontan cutthroat trout which had not been previously documented (Nielsen and Sage 2002, pp. 381, 383). More recent genetic analyses, using restriction site associated DNA (RAD) sequencing, suggest the two subspecies diverged from each other substantially longer than previously thought (Saglam et al. 2017, p. 1296). Furthermore, Saglam et al. (2017, pp. 1300–1301) suggested continued recognition of PCT as a distinct cutthroat trout group, based on his conclusion that PCT show high genetic differentiation from LCT and a clear phylogenetic signal indicating a separate evolutionary lineage from LCT. Body spotting is the primary diagnostic character distinguishing the Paiute cutthroat trout from the Lahontan cutthroat trout. Paiute cutthroat trout have been known to have up to nine body spots, but rarely more than five, whereas Lahontan cutthroat trout typically possess 50 to 100 body spots. Paiute cutthroat trout also are typically coppery to purplish-pink, whereas Lahontan cutthroat trout from comparable stream environments are normally silver-yellow to light green (USFWS 2004). Paiute cutthroat trout was first listed as Salmo clarki seleniris; however, all western North American trout have been reclassified from the genus Salmo to the genus Oncorhynchus, as summarized and adopted by the American Fisheries Society's Committee on Names of Fishes, the accepted authority on North American fish taxonomy. More recently, the species name for all cutthroat trout changed from clarki to clarkii to reflect the original spelling (USFWS 2013).

Historical Range

Paiute cutthroat trout historically occupied approximately 17.8 kilometers (km) (11.1 miles [mi.]) of stream habitat in the Silver King Creek drainage, Alpine County, California, from Llewellyn Falls downstream to barriers in Silver King Canyon; as well as the accessible reaches of three small, named tributaries: Tamarack Creek, Tamarack Lake Creek, and the lower reaches of Coyote Valley Creek downstream of barrier falls (USFWS 2013).

Current Range

Paiute cutthroat trout now occupy approximately 37.8 km (23.5 mi.) of stream habitat in five widely distributed drainages outside of their historical range. They were first established in the upper reaches of the Silver King Creek drainage (above natural barriers) in 1912, when local livestock operators transplanted fish above Llewellyn Falls. The progeny of these early transplants were then introduced into several other lakes and streams in California. Four self-sustaining populations are now established outside their local historical watershed: North Fork Cottonwood Creek, Cabin Creek, Stairway Creek, and Sharktooth Creek. Cabin Creek flows into Leidy Creek and PCT have been documented in approximately 4 km (2.5 mi) of stream from the confluence with Cabin Creek downstream to the California- Nevada border; however, it is not known if this is a self-sustaining population. On September 18, 2019, 30 PCT were translocated from Coyote Creek and placed into Silver King Creek in Long Valley marking the first time PCT have occupied their historical range since the early 1900s. An additional 44 PCT from Corral Creek were placed into Silver King Creek in Long Valley in 2020.

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Juvenile: See Adult life history.

Adult: Paiute cutthroat trout are opportunistic invertivores. Juvenile individuals less than 100 m) (3.9 in.) in length feed exclusively on small aquatic organisms, while individuals over 100 mm (3.9 in.) in length feed on terrestrial insects and larger aquatic invertebrates (USFWS 2013). Fry develop into small (35 to 40 mm [1.4 to 1.6 in.]) fingerlings by early fall (USFWS 2013). Growth rates of fingerlings and older individuals are variable, with faster and greater growth occurring in larger habitats (USFWS 2013). Growth rates also vary depending on water temperature and food availability (USFWS 2004). In stream environments, Paiute cutthroat trout seldom reach sizes in excess of 250 mm (10 in.) in total length (USFWS 2004). They attain a maximum size of 342 mm (13.5 in.) in Silver King Creek (USFWS 2004). In lakes, they may grow up to 450 mm (18 in.) or more (USFWS 2004). Paiute cutthroat trout evolved in the absence of other trout and are therefore highly susceptible to competition from introduced trout species (USFWS 2013).

Reproduction Narrative

Juvenile: See Adult life history.

Adult: Paiute cutthroat trout are obligatory stream spawners and select spawning sites based on a variety of factors, including gravel size, velocity, water depth, and water temperature. Spawning areas must be well oxygenated and relatively silt-free for good egg survival. Paiute cutthroat trout reach reproductive maturity at 2 years of age and spawn between May and June, depending on stream flow, elevation, and water temperature. Redds (nests) are generally located in riffles and pool tails. Females excavate the redd, depositing between 250 and 400 eggs in the redd while the male simultaneously fertilizes the eggs. The female then covers the fertilized eggs with gravel. Eggs hatch in 6 to 8 weeks, free emerge from the gravel 2 to 3 weeks later, and remain in shallow shoreline areas with small gravel/cobble for hiding cover. Most individuals spawn only once, although a few individuals may spawn twice. Paiute cutthroat trout may live up to 6 years (USFWS 2013).

Geographic or Habitat Restraints or Barriers

Juvenile: See Adult life history.

Adult: All populations of Paiute cutthroat trout are isolated in headwater drainages due to natural barriers (e.g., waterfalls) and manmade barriers (e.g., dams) (USFWS 2008).

Spatial Arrangements of the Population

Juvenile: Uniform during the day; fingerlings set up feeding territories during the day. Clumped at night; fingerlings may school together at night in hiding cover (USFWS 2013).

Adult: Individuals set up dominance hierarchies and defend these positions. The largest fish typically occur in pools, while smaller fish use runs, riffles, and whatever other unoccupied habitats are available (USFWS 2004).

Environmental Specificity

Juvenile: See Adult life history.

Adult: Community with key requirements common.

Site Fidelity

Juvenile: See Adult life history.

Adult: High

Habitat Narrative

Juvenile: See Adult life history.

Adult: Paiute cutthroat trout naturally occur in freshwater habitats ranging in size from creeks to medium-sized rivers with moderate gradients (NatureServe 2015). Individuals can survive in lakes, but there is no evidence that they ever occurred naturally in lakes (USFWS 2013). All life stages of Paiute cutthroat trout require cool, well-oxygenated waters (NatureServe 2015). Adults prefer stream pool habitats in low-gradient meadows with undercut or overhanging banks and abundant riparian vegetation (USFWS 2013). Individuals set up dominance hierarchies and defend these positions. The largest fish typically occur in pools, while smaller fish use runs, riffles, and whatever unoccupied habitats are available (USFWS 2004). During the winter months, trout move into pools to avoid physical damage from ice scouring and to conserve energy (USFWS 2013). Young-of-the-year fish rear in mainstem shoals of backwaters, and often move into intermittent tributary streams until they reach about 50 mm (2.0 in.) in length (USFWS 2004). Pools are important rearing habitat for juveniles, and act as refuge areas for all life stages during winter (USFWS 2013). Fingerlings set up feeding territories during the day, but school together at night in hiding cover (USFWS 2013).All populations of Paiute cutthroat trout are isolated in headwater drainages due to natural barriers (e.g., waterfalls) and manmade barriers (e.g., dams) (USFWS 2008). Individuals appear relatively tolerant to different habitats; all extant populations have been introduced to previously uninhabited drainages.

Dispersal/Migration

Motility/Mobility

Juvenile: See Adult life history.

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: See Adult life history.

Adult: Nonmigratory (USFWS 2013)

Dispersal

Juvenile: See Adult life history.

Adult: Low (USFWS 2013)

Immigration/Emigration

Juvenile: See Adult life history.

Adult: Low

Dependency on Other Individuals or Species for Dispersal

Juvenile: See Adult life history.

Adult: No

Dispersal/Migration Narrative

Juvenile: See Adult life history.

Adult: Paiute cutthroat trout were historically limited to approximately 17.8 km (11.1 mi.) of stream habitat in the Silver King Creek drainage from Llewellyn Falls downstream to barriers in Silver King Canyon, as well as the accessible reaches of three small tributaries. The species currently occupies approximately 37.8 km (23.5 mi.) of stream habitat in five drainages outside of their historical range. Due to their limited historical range, the species is naturally nonmigratory and has low dispersal and emigration. If individuals were to emigrate, they would need passable riverine habitat, which is currently lacking in all extant populations. In occupied stream reaches, limited movement of Paiute cutthroat trout has been observed in adults in

North Fork Cottonwood Creek; most individuals were recaptured in their original capture locations, but both upstream and downstream movement was detected, with a few individuals moving more than 1 km (0.6 mi.) (USFWS 2013).

Additional Life History Information

Adult: Limited movement of Paiute cutthroat trout has been observed in adults in North Fork Cottonwood Creek; most individuals were recaptured in their original capture locations, but both upstream and downstream movement was detected with a few individuals moving more than 1 km (0.6 mi.) (USFWS 2013). In 2017, 68 PCT were translocated from North Fork Cottonwood Creek to Silver King Creek in Upper Fish Valley. These fish were all marked with a fin clip and placed into Silver King Creek about mid-way between Llewellyn Falls and the most upstream barrier. During surveys in 2018, these marked fish were found dispersed throughout the entire 7 km (4.3 mi) of stream available to them including one fish near Llewellyn Falls and another at the base of the upstream-most fish barrier.

Population Information and Trends

Population Trends:

Some populations appear to be declining, while others are stable (USFWS 2020).

Species Trends:

Stable (USFWS 2008; USFWS 2013; USFWS 2020)

Resiliency:

Moderate

Representation:

Moderate

Redundancy:

Moderate

Number of Populations:

Five: Silver King Creek Drainage (consisting of five creeks), Sharktooth Creek, Stairway Creek, North Fork Cottonwood Creek, and Cabin Creek (USFWS 2013; USFWS 2020).

Population Size:

Silver King Creek Drainage – Coyote Valley Creek: The most recent population density surveys of the Coyote Valley Creek population in 2020 found 50 adults/km (80 adults/mi.) for the Lower Meadow section (which is lower than the average of 88 adults/km [141 adults/mi.]) and 28 adults/km (45 adults/mi.) in the Upper Meadow section (which is lower than the average of 112 adults/km [180 adults/mi.]). Sharktooth and Stairway Creeks: A robust population estimate does not exist for these populations. However, fly rod depletion surveys indicate that there are multiple age classes present in these populations, and although the numbers fluctuate between years, the populations appear to be stable. North Fork Cottonwood and Cabin Creeks: Visual surveys of North Fork Cottonwood Creek indicate a stable population with multiple age classes present. Visual surveys at Cabin Creek indicated that all age classes were present; however, the stability of this population is unknown (USFWS 2020).

Minimum Viable Population Size:

2, 500 (USFWS 2013; USFWS 2020)

Resistance to Disease:

Low

Additional Population-level Information:

It is difficult to characterize abundance, due to annual fluctuations in populations and variations in population estimation methods (USFWS 2013; USFWS 2020).

Population Narrative:

There are five extant populations of Paiute cutthroat trout at the following locations: Silver King Creek Drainage (consisting of five creeks), Sharktooth Creek, Stairway Creek, North Fork Cottonwood Creek, and Cabin Creek (USFWS 2013; USFWS 2020). It is difficult to characterize Paiute cutthroat trout abundance, due to annual fluctuations in populations and variations in population estimation methods (USFWS 2013; USFWS 2020). The total population is likely stable, and is estimated to be somewhere between 1,000 and 10,000 individuals (NatureServe 2015; USFWS 2013 2020). Robust population estimates are not available for Sharktooth and Stairway Creeks; however, surveys indicate that there are multiple age classes present, that populations fluctuate annually, and that the populations are generally stable (USFWS 2013 2020). The population at North Fork Cottonwood Creek appears to have a stable population with multiple age classes. The population at Cabin Creek has all age classes present, but its stability is unknown. The populations in the Silver King Creek Drainage are better studied and have density estimates over multiple years. The Silver King Creek (Upper Fish Valley) population, which was reintroduced between 1994 and 1998. The mean for the entire population (adults and juveniles) over a 56-year period (1964–2020) is 798 individuals while the mean for the adult population is 392 individuals (USFWS 2020). The most recent population estimate was 132 adults in 2020. The Fly Valley Creek population averaged 92 adults/km (147 adults/mi.) between 1984 and 2020 and was most recently 46 adults/km (74 adults/mi.) in 2020. The population at Four Mile Canyon has averaged 49 adults/km (79 adults/mi.) between 1968 and 2020, but appears to be declining in population; in 2020, a total of five one adults was found in all available habitat (1,555 m [5,201 ft.]). The population at Corral Valley Creek has averaged 59 adults km (95 adults/mi.) between 1974 and 2020, and was most recently 51 adults/km (83 adults/mi.) in 2020. The most recent population density surveys of the Coyote Valley Creek population, in 2020, found 50 adults/km (80 adults/mi.) for the Lower Meadow section (which is lower than the average of 88 adults/km [141 adults/mi.]) and 28 adults/km (45 adults/mi.) in the Upper Meadow section (which is lower than the average of 112 adults/km [180 adults/mi.]) (USFWS 2020).To ensure long-term persistence, it was estimated that a population should consist of at least 2,500 cutthroat trout, and that at least 8.2 km (5.1 mi.) of habitat is required to maintain a population of that size when fish density was high (300 fish/km; 484 fish/mi.). Adding a 10 percent loss rate of individuals to account for emigration and mortality increased the required length to 9.3 km (5.8 mi.) to maintain 2,500 fish. For streams with smaller population densities of 200 fish/km (320 fish/mi.) and 100 fish/km (160 fish/mi.), the corresponding stream length increased to 12.5 km (7.8 mi.) and 25 km (15.5 mi.), respectively, to maintain a population of 2,500 (USFWS 2013).

Threats and Stressors

Stressor: Nonnative fish
Exposure: Introduction of nonnative fish.
Response: Loss of habitat, and range constrictions.
Consequence: Extirpation
Narrative: Nonnative salmonid species are currently the greatest threat to Paiute cutthroat trout, resulting in loss of available habitat and range constrictions primarily through hybridization. The introduction of nonnative fish has been documented as a global threat to native fish species. Silver King Creek has a long and complicated history of trout management. Five different trout species have been moved into and around the Silver King drainage, including Paiute cutthroat trout, Lahontan cutthroat trout, California golden trout, rainbow trout, and brook trout. Paiute cutthroat trout were extirpated from their historical habitat due to introduced trout, but exist in formerly fishless areas of the Silver King Creek drainage and four out-of-basin watersheds above fish passage barriers (USFWS 2013). Between 2013 and 2015, nonnatives were removed from the PCT's historical range using piscicides. In 2019, 30 PCT were translocated from Coyote Creek and placed into Silver King Creek and an additional 44 were translocated from Corral Creek in 2020 (USFWS 2020).

Stressor: Hybridization with nonnative salmonids
Exposure: Presence of nonnative trout.
Response: Hybridization, decrease in fitness and survival rates, and loss of locally adapted genotype.
Consequence: Extinction of a population or species.
Narrative: Hybridization of nonnative salmonids is a common threat to all native western salmonid species. Nonnative rainbow trout and golden trout readily hybridize with native cutthroat trout and produce fertile offspring; however, fitness and survival rates decreases as the proportion of rainbow trout admixture increases. Even with reduced fitness, hybridization spreads rapidly because the initial F1 (first generation) hybrids have high fitness, hybrids tend to stray more frequently, and all offspring of hybrids are hybrids. Extensive genetic mixing of natives, nonnatives, and hybrids contribute to the loss of locally adapted genotypes and can lead to the extinction of a population or an entire species. As indicated by a recent genetic analysis, hybridization by nonnative species has eliminated Paiute cutthroat trout from their entire historical habitat. Between 2013 and 2015, nonnatives were removed from the PCT's historical range using piscicides. In 2019, 30 PCT were translocated from Coyote Creek and placed into Silver King Creek and an additional 44 were translocated from Corral Creek in 2020 (USFWS 2020). Cabin Creek is the only population of PCT which doesn't have rainbow trout in stream reaches downstream of occupied habitat (USFWS 2013; USFWS, 2020).

Stressor: Population isolation and habitat fragmentation
Exposure: Population isolation and habitat fragmentation.
Response: Lack of gene flow, and reduction in habitat quality.
Consequence: Reduced fitness, and elevated risk of extirpation due to stochastic events.
Narrative: All existing populations of Paiute cutthroat trout are isolated in headwater drainages. This makes each of them highly susceptible to extinction because of the small amount of habitat, small populations, lack of habitat connectedness, lack of gene flow between populations, and threat of a large disturbance such as floods and fire. Paiute cutthroat trout, to a degree, will always be susceptible to stochastic events because of their limited range. Habitat fragmentation is one of the leading causes of cutthroat trout population declines in the western United States.

Habitat fragmentation reduces the total habitat available, reduces habitat complexity, and prevents gene flow. Fragmentation accelerates extinction, especially when movement of fish among stream segments is not possible, which is the case with all Paiute cutthroat trout populations. Isolated populations are vulnerable to extinction through demographic stochasticity (random fluctuations in birth and death rates); environmental stochasticity (random variation in environmental attributes) and catastrophes; loss of genetic heterozygosity (genetic diversity) and rare alleles (inherited forms of a genetic trait); and human disturbance. Paiute cutthroat trout is one of the most imperiled native fish in California due to loss of genetic diversity and habitat fragmentation. Evidence of loss of genetic diversity has been found in all populations. All current Paiute cutthroat trout populations are completely isolated from each other, which does not allow for genetic exchange or recolonization after a disturbance. Apart from the isolation that habitat fragmentation causes, the short length of stream segments and small population sizes that they support are of concern for Paiute cutthroat trout (USFWS 2008; USFWS 2013; USFWS, 2020).

Stressor: Livestock grazing
Exposure: Livestock grazing in riparian areas.
Response: Alterations to or reductions of riparian habitat.
Consequence: Reductions in habitat quality, including less cover, higher temperatures, and sedimentation.
Narrative: Livestock grazing can have adverse impacts on stream habitat and fish populations. Cattle are attracted to riparian habitat due to the presence of water, shade, succulent vegetation, and gentle topography, and therefore riparian areas are particularly vulnerable to overgrazing. Livestock grazing can affect riparian areas by changing, reducing, or eliminating vegetation, and by the actual loss of riparian areas through channel widening, channel degradation, or lowering of the water table. Effects of fish habitat include reduction of shade and cover and resultant increases in water temperature, changes in stream morphology, and the addition of sediment due to bank degradation and offsite soil erosion. Livestock grazing has been a past threat to Paiute cutthroat trout; however, either grazing has been eliminated from occupied habitat or conservative grazing management objectives are in place for active grazing allotments (USFWS 2013; USFWS 2020).

Stressor: Disease
Exposure: Fungal infections in North Fork Cottonwood Creek population.
Response:
Consequence: Potentially reduced fitness of North Fork Cottonwood Creek population.
Narrative: Disease is apparently a significant cause of adult Paiute cutthroat trout mortality in North Fork Cottonwood Creek, particularly in the post-spawning period. Extensive fungal infections have been observed on the dorsal and caudal fins of several spawned-out fish in North Fork Cottonwood Creek. Many of these fish were so weakened by spawning that they were unable to recover. It is unknown how this infection affects Paiute cutthroat trout at the population level; however, it should be noted that the population has persisted in North Fork Cottonwood Creek since the fungus was first observed in the early 1970s. This disease has not been observed outside of North Fork Cottonwood Creek; therefore, disease does not seem to be a significant threat to the species throughout its current range (USFWS 2013; USFWS 2020).

Stressor: Climate change
Exposure: Climate change.

Response: Predicted increased stream temperatures, decreased flow, changes in hydrograph, and increased numbers of extreme events.
Consequence: Potential for reduced habitat quality and quantity, as well as thermal stress.
Narrative: The impacts to Paiute cutthroat trout from climate change are not known with certainty. Predicted outcomes of climate change imply that negative impacts will occur through increased stream temperatures, decreased stream flow, changes in the hydrograph, and increased frequency of extreme events. Water temperatures are expected to increase in the future; however, because all occupied Paiute cutthroat trout habitat is above 2,438 meters (m) (8,000 feet [ft.]), stream temperatures are not likely to rise above critical thresholds. Rising stream temperatures may increase their susceptibility to various diseases which are not current threats. Reductions in streamflow through changes in the hydrograph and drought are predicted to have a negative impact on Paiute cutthroat trout populations because of the fragmented nature of Paiute cutthroat trout populations, the small size of occupied stream habitats, and the close association of recruitment and survival to stream flow. Although Paiute cutthroat trout evolved in a fire-prone environment, increases in wildfire frequency and severity due to increased fuel loads and effects from climate change have increased the threats due to wildfire. Current wildfires are a larger threat to Paiute cutthroat trout because of the current fragmented and isolated state of occupied habitat (USFWS 2013; USFWS 2020).

Recovery

Reclassification Criteria:
Paiute cutthroat trout are currently listed as threatened under the federal Endangered Species Act. No reclassification criteria have been established for this species.

Recovery Priority Number: 9

Delisting Criteria:
The objective of the recovery plan is to recover Paiute cutthroat trout by improving its status and habitat and eliminating nonnative salmonids so it can be delisted. Criteria for accomplishing the goal of delisting are:

All nonnative salmonids are removed from Silver King Creek and its tributaries downstream of Llewellyn Falls to fish barriers in Silver King Canyon (USFWS 2004; USFWS 2013; USFWS 2020).

A viable population occupies all historical habitat in Silver King Creek and its tributaries downstream of Llewellyn Falls to fish barriers in Silver King Canyon.

Paiute cutthroat trout is maintained in all occupied streams (USFWS 2004; USFWS 2013; USFWS 2020).

The refuge populations in Corral and Coyote creeks, Silver King Creek, and tributaries above Llewellyn Falls as well as out-of-basin populations are maintained as refugia and are secured from the introduction of other salmonid species (USFWS 2004; USFWS 2013; USFWS 2020).

A long-term conservation plan and conservation agreement are developed, which will be the guiding management documents once Paiute cutthroat trout are delisted (USFWS 2004; USFWS 2013; USFWS 2020).

Recovery Actions:

- Remove nonnative fish from Silver King Creek downstream of Llewellyn Falls to barriers in Silver King Canyon (USFWS 2004).
- Reintroduce Paiute cutthroat trout into renovated stream reaches in historic habitat (USFWS 2004).
- Protect and enhance all occupied Paiute cutthroat trout habitat (USFWS 2004).
- Continue to monitor and manage existing and reintroduced populations (USFWS 2004).
- Develop a long-term conservation plan and conservation agreement (USFWS 2004).
- Inform the public of Paiute cutthroat trout recovery objectives and pertinent management activities (USFWS 2004).
- Continue reintroducing PCT into their historical habitat following recommendations in the Genetics Management Plan (Finger et al. 2013, entire). Implementation will fulfill Recovery Criteria 2 in the Revised Recovery Plan (USFWS 2020).
- Environmental DNA sampling and evaluating the barriers in Silver King Gorge will be essential activities to ensure that nonnative rainbow trout do not reinvade the PCT historical range. Environmental DNA sampling is a proven technique to detect nonnative rainbow trout and should be continued. Evaluation of the existing barriers to ensure they are functioning properly is an important task. The success of the Paiute Cutthroat Trout Restoration Project depends on the effectiveness of the barriers in keeping nonnative rainbow trout from reinvading the historical range of PCT. Implementation will help fulfill Recovery Criteria 4 in the Revised Recovery Plan (USFWS 2020).
- Habitat monitoring was conducted in the late 1980s, 1990s, and early 2000s by agency researchers. Valuable baseline habitat information was collected at this time. Changes in habitat have been occurring since cessation of livestock grazing in 1995. Documenting changes in habitat will help fulfill Recovery Criteria 3 in the Revised Recovery Plan (USFWS 2020).
- Population estimates for PCT are routinely conducted in low stream gradient meadow habitat. Fish densities are known to decrease in higher gradient portions of occupied streams but the extent of this decrease is unknown. To better understand population dynamics in all habitat types of Silver King Creek and its tributaries, population monitoring should also include higher gradient sections. A better understanding of population dynamics will help fulfill Recovery Criteria 2 (USFWS 2020).
- Out-of-basin populations in Sharktooth Creek and Stairway Creek on the Sierra National Forest have not been visited since 2012. Population and habitat surveys should be made a priority, particularly since Stairway Creek watershed burned in 2018. Little is known about Paiute cutthroat trout or habitat conditions in Leidy Creek on the Inyo National Forest. Continue to collect population and distribution data for Leidy Creek and collect baseline habitat data to better inform management. Implementation will fulfill Recovery Criteria 4 in the Revised Recovery Plan (USFWS 2020).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS 1. Implement the Paiute Cutthroat Trout Restoration Project. Continue reintroducing PCT into their historical habitat following recommendations in the Genetics Management Plan (Finger et al. 2013, entire). Implementation will fulfill Recovery Criteria 2 in the Revised Recovery Plan (Service 2004, pp. 49–50). 2. Continue monitoring the historical range for reinvasion by nonnative rainbow trout. Environmental DNA sampling and evaluating the barriers in Silver King Gorge will be essential activities to ensure that nonnative rainbow trout do not reinvade the PCT historical range. Environmental DNA sampling is a proven technique to detect nonnative rainbow trout and should be continued. Evaluation of the existing barriers to ensure they are functioning properly is an important task. The success of the Paiute Cutthroat Trout Restoration Project depends on the effectiveness of the barriers in keeping nonnative rainbow trout from reinvading the historical range of PCT. Implementation will help fulfill Recovery Criteria 4 in the Revised Recovery Plan (Service 2004, pp. 51, 59). 3. Reevaluate habitat conditions in Silver King Creek. Habitat monitoring was conducted in the late 1980s, 1990s, and early 2000s by agency researchers (Duff 1991, pp. 1–11; Overton et al. 1994, pp. 1–27; Flint 2004, pp. 1–14). Valuable baseline habitat information was collected at this time. Changes in habitat have been occurring since cessation of livestock grazing in 1995. Documenting changes in habitat will help fulfill Recovery Criteria 3 in the Revised Recovery Plan (Service 2004, pp. 49, 51). 4. Improve population estimates in Silver King Creek drainage. Population estimates for PCT are routinely conducted in low stream gradient meadow habitat. Fish densities are known to decrease in higher gradient portions of occupied streams but the extent of this decrease is unknown. To better understand population dynamics in all habitat types of Silver King Creek and its tributaries, population monitoring should also include higher gradient sections. A better understanding of population dynamics will help fulfill Recovery Criteria 2 (Service 2004, pp. 50, 52–53). 5. Evaluate populations in Sharktooth, Stairway, and Leidy Creeks. Out-of-basin populations in Sharktooth Creek and Stairway Creek on the Sierra National Forest have not been visited since 2012. Population and habitat surveys should be made a priority, particularly since Stairway Creek watershed burned in 2018. Little is known about Paiute cutthroat trout or habitat conditions in Leidy Creek on the Inyo National Forest. Continue to collect population and distribution data for Leidy Creek and collect baseline habitat data to better inform management. Implementation will fulfill Recovery Criteria 4 in the Revised Recovery Plan (Service 2004, pp. 61–62).

Additional Threshold Information:

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N/A

SPECIES ACCOUNT: *Oncorhynchus clarkii virginalis* (Rio Grande cutthroat trout)

Species Taxonomic and Listing Information

Listing Status: Candidate

Physical Description

Cutthroat trout are distinguished by the red to orange slashes in the folds beneath the lower jaw (Behnke 2002, p. 139) (Figure 2). Rio Grande cutthroat trout have irregular shaped spots that are concentrated behind the dorsal fin, smaller less numerous spots located primarily above the lateral line in front of the dorsal fin, and basibranchial teeth that are minute or absent (Sublette et al. 1990, p.53; Behnke 2002, p. 207). Rio Grande cutthroat trout are light rose to red-orange on the sides and pink or yellow-orange on the belly (USFWS, 2014).

Taxonomy

The currently accepted subspecies classification is: Class: Actinopterygii Order: Salmoniformes Family: Salmonidae Species: Oncorhynchus clarkii virginalis Girard, 1856 (USFWS, 2014).

Historical Range

Rio Grande cutthroat trout are generally assumed to have occupied all streams capable of supporting trout in the Rio Grande, Pecos, and Canadian basins (Alves et al. 2007, p. 9). The Pecos River is a tributary of the Rio Grande, so a historical connection between the two basins likely existed. Although no early museum specimens document its occurrence in the headwaters of the Canadian River, there is no evidence of human introduction and so it is almost certainly native there as well (Behnke 2002, p. 208; Pritchard et al. 2009, p. 1219). The Canadian River, which drains to the Mississippi River basin, has no connection with the Rio Grande. It is possible that through headwater capture (a tributary from one watershed joins with a tributary from another) there may have been natural migration of fish between the Pecos and Canadian headwater streams. Because there are Rio Grande cutthroat trout populations throughout the headwaters of the Rio Grande basin, historically, these fish most likely dispersed through the Rio Grande into the tributary streams. There is some possibility that Rio Grande cutthroat trout may have occurred in the Pecos River basin in Texas (Behnke 1967, pp. 5, 6; Garrett and Matlock 1991, p. 404) and the Rio Grande basin in Mexico (Behnke 1967, p. 4). However, no specimens were collected to document their presence in these locations with certainty. Their potential occupancy in these locations is based on fluvial connections and on historical articles that describe the presence of trout that could have been Rio Grande cutthroat trout. The range of the Rio Grande cutthroat trout has been divided by basins into five geographic management units (GMUs) to bring a greater resolution to descriptions of population and habitat distribution and related maintenance and restoration work (Figure 3). These GMUs reflect the hydrologic divisions of the Rio Grande cutthroat trout's historical range by river drainage. The GMUs are managed by the Conservation Team as separate units to maintain genetic and ecological diversity within the subspecies where it exists and to ensure representation of the subspecies across its historical range. However, the GMUs were not created to necessarily reflect important differences in genetic variability in the subspecies based on geography or adaptation to specific environments, although fish in the Pecos and Canadian GMUs do exhibit some genetic differentiation from those in the Rio Grande GMUs (Pritchard et al. 2009, p. 1216). Additionally, Rio Grande cutthroat trout are only known from one stream in the Caballo GMU – Las Animas Creek, where a hybridized population currently exists. No other historical locations are known within that GMU (USFWS, 2014).

Current Range

Rio Grande cutthroat trout are only known from one stream in the Caballo GMU – Las Animas Creek, where a hybridized population currently exists (USFWS, 2014).

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Food Source

Adult: Most cutthroat trout are opportunistic feeders, eating both aquatic invertebrates and terrestrial insects that fall into the water (Sublette et al. 1990, p. 54). As individuals grow they may exhibit more benthic feeding (Pritchard and Cowley 2006, p. 25). Cutthroat trout subspecies generally become more piscivorous (fish eating) as they mature (USFWS, 2014).

Competition

Adult: Competition with non-native species (mainly rainbow and brown trout) (USFWS, 2014).

Reproductive Strategy

Adult: Oviparity

Lifespan

Adult: Up to 8 years (USFWS, 2014).

Breeding Season

Adult: Spawning occurs from Middle of May to Middle of June (USFWS, 2014).

Reproduction Narrative

Adult: Rio Grande cutthroat trout exhibit a life history similar to other cutthroat trout subspecies. Adults spawn as high water flows from snowmelt recede, which typically occurs from the middle of May to the middle of June (NMDGF 2002, p. 17). Spawning is believed to be tied to day length, water temperature, and runoff (Sublette et al. 1990, p. 54; Behnke 2002, p. 141). It is unknown if Rio Grande cutthroat trout spawn every year or if some portion of the population spawns every other year as has been recorded for westslope cutthroat trout (O. c. lewisi) (McIntyre and Rieman 1995, p. 1). Likewise, while it is assumed that females mature at age 3, they may not spawn until age 4 or 5 as seen in westslope cutthroat trout (McIntyre and Rieman 1995, p. 3). Individuals greater than 120 millimeters (mm) (4.7 inches (in)) are considered adults (Pritchard and Cowley 2006, p. 25). Adults have been observed as old as 8 years.   A female constructs the nest (redd) just prior to spawning and deposits 200 – 4,500 eggs in it, which are then fertilized by a male (Cowley 1993, p. 3). Rio Grande cutthroat trout do not exhibit parental care of the redd or young. Depending on water temperature, the eggs hatch within 3 – 7 weeks (Prichard and Cowley 2006, p. 26). The hatchlings remain within the gravel of the redd for several weeks until the yolk sac is absorbed (Pritchard and Cowley 2006, p. 26). Sex ratio also is unknown with certainty, but based on field data, a ratio skewed towards more females might be expected (Pritchard and Cowley 2006, p. 27). Although Yellowstone (O. c. bouvieri) (Gresswell 1995, p. 36), Bonneville (O. c. utah) (Schrank and Rahel 2004, p. 1532), and westslope (Bjornn and Mallet 1964, p. 73; McIntyre and Rieman 1995, p. 3) cutthroat trout subspecies are known to have a migratory life history phase, in which the trout will move between lakes and rivers, it is not known if Rio Grande cutthroat trout once had a migratory form when there was connectivity among watersheds. There are no migratory populations today (USFWS, 2014).

Habitat Type

Adult: Stream

Spatial Arrangements of the Population

Adult: Clumped

Environmental Specificity

Adult: Narrow/specialist

Site Fidelity

Adult: High

Habitat Narrative

Adult: As is true of other subspecies of cutthroat trout, Rio Grande cutthroat trout are found in clear, cold, high elevation streams. Much of what is known of Rio Grande cutthroat trout life history is from studies of other cutthroat trout subspecies, and we presume that this knowledge applies to Rio Grande cutthroat trout. Rio Grande cutthroat trout require several types of habitat for survival: spawning habitat, nursery or rearing habitat, adult habitat, and refugial habitat (organized by life stage in Table 1). Rio Grande cutthroat trout spawn as floods from snowmelt runoff recede. Spawning habitat is found in areas exposed to flowing water with clean gravel (little or no fine sediment present) that ranges between 6 – 40 millimeters (mm) (0.24 – 1.6 inches (in)) in diameter (NMDGF 2002, p. 17; Budy et al. 2012, p. 437, 447) where redds are formed (Cowley 1993, p. 3). Embryonic development of cutthroat trout within eggs requires flowing water with high oxygen levels (Cowley 1993, p. 3; Budy et al. 2012, p. 437). Fry emerge after yolk absorption and at a length of about 20 mm (0.8 in) (USFWS, 2014).

Dispersal/Migration

Motility/Mobility

Adult: High (within its habitat)

Dispersal/Migration Narrative

Adult: Currently 84 conservation populations have complete or partial fish migration barriers, reducing risk of hybridizing species invasion (USFWS, 2014).

Population Information and Trends

Population Trends:

Declining

Resiliency:

Moderate The factors threatening these populations generally have a relatively low risk of occurrence; however, if the stochastic events occur, they potentially have a high risk of resulting in substantial effects to a population, which could possibly result in extirpation (see Chapter 4 and Appendix B for a discussion of these factors). This relationship makes determining the cumulative risk of these stressors particularly difficult to assess and predict the outcome. Additionally, we were not able to quantitatively account for all potential synergistic effects between the risk factors due to the limitations in our analytical process. However, our probability of persistence module incorporates the risks in an explicit way to assess the estimated resiliency of the Rio Grande cutthroat trout (USFWS, 2014).

Representation:

High In considering the estimated persistence probabilities and their locations, we provide a picture of the future representation of the subspecies potential ecological diversity across its range to 2080 (Figures 5–15). For example, Figures 12 and 19 show the persistence probability of populations in the Lower Rio Grande GMU, where persistence probabilities appear to decline the most over time in our model. The map in Figure 13 would indicate that the variation in persistence probabilities is distributed across the GMU so that none of the risk is associated with any particular geographic area within the GMU. The number of surviving populations by GMU (Figures 15 and 16) also provides an estimate for the future geographic variation that is expected to survive through 2080 and suggests that, even under the worst case scenarios, populations will persist across the range of the subspecies (USFWS, 2014).

Redundancy:

High The subspecies currently has approximately 122 populations distributed across the four GMUs (Table 4), with populations per GMU ranging from 10 to 59 (USFWS, 2014).

Number of Populations:

• 122 Extant Populations across range. * 55 (45%) of populations are currently in the best or good condition (based on absence of nonnative trout, effective population size, and occupied stream length) * 67 (55%) of populations are currently in fair or poor condition. (USFWS, 2014)

Population Narrative:

We used the results of the persistence probabilities along with the number of estimated future restored populations to predict the number and location of future surviving populations by GMU under a range of possible conditions. The results suggest that, depending on the particular scenario considered related to risk factors and restoration efforts, the overall number of populations rangewide surviving by 2080 range from a low of 50 under the worst case scenario to a high of 132 under the best case scenario, with 68 in the intermediate case (Table 4). Some GMUs may decline more than others; for example, our forecasts suggest the Lower Rio Grande GMU could have the largest decline (Figure 16); we estimate the 59 current populations could decline to between 21 and 47 populations by 2080 (Table 4). The GMU with the least populations, the Canadian GMU (with 10 current populations), is forecasted to range between 3 and 14 populations by 2080 (Table 4). Based on our forecasts of persisting populations by 2080, it seems unlikely that a catastrophic event would eliminate the species from an entire GMU, because our forecasts suggest that populations will remain distributed throughout the four

GMUs (USFWS, 2014).

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2014. Species Status Assessment Report for the Rio Grande Cutthroat Trout. USFWS Region 2. Albuquerque, NM.

SPECIES ACCOUNT: *Oncorhynchus gilae* (Gila trout)

Species Taxonomic and Listing Information

Listing Status: Threatened; with Special Rule (4d) for hatchery populations, July 18, 2006 (71 FR 40657).

Physical Description

Gila trout is readily identified by its iridescent gold sides, which blend to a darker shade of copper on the opercles. Spots on the body of this trout are small and profuse, generally occurring above the lateral line and extending onto the head, dorsal fin, and caudal fin. Spots are irregularly shaped on the sides and increase in size dorsally. On the dorsal surface of the body, spots may be as large as the pupil of the eye and are rounded. A few scattered spots are sometimes present on the anal fin, and the adipose fin is typically large and well-spotted. Parr marks are commonly retained by adults, although they may be faint or absent. Dorsal, pelvic, and anal fins have a white to yellowish tip that may extend along the leading edge of the pelvic fins (USFWS 2003).

Taxonomy

The Gila trout is a member of the salmon and trout family (Salmonidae). It is most closely related to Apache trout (Oncorhynchus apache), which is endemic to the upper Salt and Little Colorado river drainages in east-central Arizona. Gila trout and Apache trout are more closely related to rainbow trout (O. mykiss) than to cutthroat trout (O. clarki), suggesting that Gila and Apache trout were derived from an ancestral form that also gave rise to rainbow trout. Morphological characteristics that distinguish Gila trout (Oncorhynchus gilae) from other co-occurring nonnative trout (rainbow, brown, and cutthroat trout) include the golden coloration of the body, parr marks, and fine, profuse spots above the lateral line (USFWS 2003).

Historical Range

Gila trout is endemic to moderate- to high-gradient perennial mountain streams above 1,660 meters (m) (5,400 feet [ft.]) elevation in the Gila, San Francisco, Agua Fria, and Verde river drainages in New Mexico and Arizona. The species historically occurred in mountain stream habitats in Sierra, Grant, and Catron counties in New Mexico; and Greenlee, Apache, Graham, Gila, and Yavapai counties in Arizona (USFWS 2003).

Current Range

The occupied range of Gila trout has fluctuated since 1975, when only five populations of the species were known. Range expansions resulted when new populations were established through stocking conducted by resource management agencies. Range reductions occurred from local extirpations caused by high-intensity forest fires and hybridization with rainbow trout (O. mykiss). Rainbow trout gained access to Gila trout streams through illegal stocking or by natural immigration over what were thought to be barriers to fish movement. By June 2000, Gila trout inhabited approximately 105 kilometers (km) (65 mile [mi.]) of habitat in 14 streams. The species occurs in Sierra, Grant, and Catron counties, New Mexico; and in Gila and Greenlee counties, Arizona (USFWS 2003).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Gila trout are generally opportunistic feeders, primarily preying on insects between the hours of 9:00 a.m. and 1:00 p.m. (NatureServe 2015). The diet of Gila trout shifts on a seasonal basis as the relative abundance of various prey taxa change. However, the species coevolved with several other fishes, and there is some evidence of piscivory in Gila trout. Large Gila trout occasionally consume speckled dace and may also cannibalize smaller Gila trout. It has been noted that Gila trout established a feeding hierarchy in pools during a low flow period in Main Diamond Creek. Larger fish aggressively guarded their feeding stations and chased away smaller fish. Nonnative brown trout (Salmo trutta) tend to be predatory and out-compete Gila trout for food and space (USFWS 2003).

Reproduction Narrative

Adult: Gila trout broadcast spawn in April; spawning behavior is typical of other salmonids. Spawning begins when temperatures reach about 8 °C (46 °F), but day length may also be an important cue. Stream flow is apparently of secondary importance in triggering spawning activity. Female Gila trout typically construct redds in water 6 to 15 centimeters (cm) (2.4 to 6 in.) deep within 5 m (16 ft.) of cover. Nests are 3 to 4 cm (1.2 to 1.6 in.) deep in fine gravel and coarse sand substrate (i.e., particle size ranging from 0.2 to 3.8 cm [0.08 to 1.5 in.] diameter). Redd size varies from less than 0.1 to 2.0 square m (1.1 to 21.5 square ft.). Spawning activity typically occurs between 1:00 p.m. and 4:00 p.m. Fry (20 to 25 mm [0.8 to 1.0 in.] total length) emerge from redds in 56 to 70 days. Females reach maturity between 2 to 4 years, with a minimum length of about 130 mm (5 in.) reported. However, most individuals are mature at a length of 15 cm (6 in.). Males typically reach maturity at age 2 or 3. Fecundity is dependent on body size and condition. It has been reported that the individual fecundity is about 62 for Gila trout 10 to 15 cm (4 to 6 in) total length, and 197 for Gila trout greater than 15 cm (6 in.) total length. Most adult Gila trout live to about age 5, with a maximum age of 9. The majority of adult female Gila trout only spawn twice before dying, and most adult males only spawn three or four times before dying (USFWS 2003). Egg production is considered low (usually a few hundred or fewer) (NatureServe 2015).

Geographic or Habitat Restraints or Barriers

Adult: Gila trout are restricted from warmer water environments where they are in competition with nonnative salmonids. Artificial barriers have been constructed on a number of Gila trout streams to limit overlap between Gila trout and rainbow or brown trout, and to retain genetically distinct populations (USFWS 2003).

Spatial Arrangements of the Population

Adult: Clumped into suitable habitats within the species range.

Environmental Specificity

Adult: Suitable substrate composition for development of eggs and embryos is characterized by approximately 7 percent or less fines (particles less than 1 mm [0.04 in.] diameter) by weight. Coarse sands and gravels ranging from 1 mm (0.04 in.) to 18 mm (0.7 in.) in diameter compose approximately 60 percent of the substrate in habitat suitable for eggs and embryos (USFWS 2003).

Tolerance Ranges/Thresholds

Adult: Moderate

Dependency on Other Individuals or Species for Habitat

Adult: The presence of rainbow or brown trout (O. mykiss or Salmo trutta) has negative consequences on the Gila trout (USFWS 2003).

Habitat Narrative

Adult: Gila trout are found in high- to moderate-gradient, clear, cold mountain streams, riffles, and pools that are typically narrow and shallow in arid regions. Streams may be perennial to intermittent (not flowing in summer and fall); the species may be confined to pools during prolonged drought. High stream discharge variability is a defining characteristic of the environment to which Gila trout has adapted. The species usually congregates in deeper pools, and is found in shallow water only where protective debris or plant beds are present. Long-term discharge data from streams inhabited by or suitable for Gila trout are lacking. During low-flow years, marginal habitats may become too warm to support trout, or surface flow may cease and stream segments may dry. Pool depth may diminish to the extent that winter mortality of trout is greatly increased. Large-magnitude flood events during high flow years may scour stream channels and eliminate year classes of trout. These frequent, recurring extremes in flow conditions are a basic element of the relatively harsh environment that distinguishes habitat of Gila trout from the typical trout streams of more northern latitudes (USFWS 2003).Essential habitat elements for Gila trout center on maintenance of adequate dissolved oxygen concentration, circulation of fresh water in the stream substrate, and absence of gametes of rainbow trout (O. mykiss) available for fertilization of Gila trout eggs. Rainbow and Gila trout have concurrent spawning periods; therefore, rainbow trout may fertilize eggs of Gila trout and vice versa, resulting in hybrid offspring. Suitable substrate composition for development of eggs and embryos is characterized by approximately 7 percent or less fines (particles less than 1 mm [0.04 in.] diameter) by weight. Coarse sands and gravels ranging from 1 mm (0.04 in.) to 18 mm (0.7 in.) in diameter compose approximately 60 percent of the substrate in habitat suitable for eggs and embryos. Essential elements of subadult and adult habitat relate principally to channel dimensions, cover, and hydrologic variability. Absence of competition with brown trout (Salmo trutta) for foraging habitat is also an essential element of subadult and adult habitat. Subadult Gila trout occur primarily in riffles; adults are found mainly in pools. Cover is an important component in both riffle and pool habitat. Size of Gila trout is positively correlated with maximum pool depth; individuals larger than 200 mm (8 in.) total length are typically found in pools that are 0. 5 m (1.6 ft.) deep or deeper. Pool depth in suitable habitats is generally 0.3 m (1 ft.) or greater. Areas in pools with current velocities ranging from 0 to 0.1 m/sec (0 to 0.3 ft./sec) adjacent to areas of swifter flow provide locations where trout can rest and obtain food from drift. Large, woody debris has been identified as an important component of pool habitat, in terms of both pool formation and providing cover.Habitat of Gila trout consists of perennial montane streams ranging from 1,660 m (5,400 ft.) to more than 2,800 m (9,200 ft.) elevation. Suitable stream habitat within the range of the species is situated between about 33° to near 35° North latitude and 107° 45' to near 112° 15' West longitude. Streams with suitable habitat for Gila trout are found in coniferous and mixed woodland, montane coniferous forest, and subalpine coniferous forest. Coniferous and mixed woodland vegetation occur at lower elevations and on southern exposures within the range of Gila trout. Dominant tree species in the coniferous and mixed woodland are piñon (Pinus edulis), juniper (Juniperus sp.), and oak (Quercus sp.). Montane coniferous forest occurs up to about 3,048 m (10,000 ft.) elevation. Below 2,591 m (8,500 ft.) elevation, this forest is characteristically dominated by ponderosa pine (Pinus ponderosa). Above about 2,438 m (8,000 ft.) elevation, Douglas-fir (Pseudotsuga menziesii), white fir (Abies concolor), blue spruce (Picea pungens), and aspen (Populus tremuloides) are common. Subalpine coniferous forest is characterized by Engelmann spruce (Picea engelmannii) and corkbark fir (Abies lasiocarpa), and is generally found from about 2,896 m (9,500 ft.) elevation to the timberline. Riparian habitats include the montane riparian vegetation and the arctic-boreal and cold-temperate riparian communities.

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory but with seasonal movements.

Dispersal

Adult: Low

Immigration/Emigration

Adult: Gila trout may immigrate into suitable streams that contain the essential habitat elements necessary for their survival.

Dispersal/Migration Narrative

Adult: Adult Gila trout are typically quite sedentary, and movement is influenced by population density and territoriality. However, individual fish may move considerable distances (i.e., more than 1.5 km [0.9 mi.]). Gila trout showed a tendency to move upstream in South Diamond Creek, possibly to perennial reaches with suitable pool habitat, in response to low summer discharge. Gila trout movement was predominately in a downstream direction in Main Diamond and McKnight creeks. Most of these fish were 1- or 2-year-old Gila trout. High density of log structures in Main Diamond Creek appeared to reduce mobility of Gila trout in that stream. Data collected from White Creek in 1999 and 2000 indicate that dispersal by Gila trout is slow, even when there are no physical barriers to movement (USFWS 2003).

Additional Life History Information

Adult: Data collected from White Creek in 1999 and 2000 indicate that dispersal by Gila trout is slow, even when there are no physical barriers to movement, and that downstream dispersal of Gila trout is limited (USFWS 2003).

Population Information and Trends

Population Trends:

Stable (NatureServe 2015)

Species Trends:

Stable (NatureServe 2015)

Number of Populations:

23 (USFWS, 2022)

Population Size:

The total population of Gila trout is estimated between 2,500 and 10,000. The population from 1974 through 1976 census was less than 7,600, with 4,750 in Main Diamond Creek, New Mexico. The estimated population was less than 10,000 in 1992, and 37,000 in 1998 (NatureServe 2015).

Minimum Viable Population Size:

Some studies have found that small populations (fewer than 2,500 individuals, yielding an effective population [Ne] of fewer than 500) are subject to increased risk of extinction (USFWS 2003).

Adaptability:

High

Additional Population-level Information:

The changes in density of Gila trout in appear to be regulated primarily by the hydrologic regime, which acts as a major influence on mortality rate. Catastrophic events have a much larger influence on the viability of Gila trout populations than do population size, fecundity, or population structure. In November 1970, 307 Gila trout were transplanted from Main Diamond Creek to McKnight Creek. The population declined to about 20 fish in 1971, concurrent with a period of low total annual stream discharge. An additional 110 Gila trout were translocated from Main Diamond Creek to McKnight Creek in April 1972, and the population increased substantially from 1974 to 1976. The population remained relatively stable from 1977 to 1984. Flood flows occurred in December 1984 that dramatically reduced the number of age 1 fish. The population of Gila trout then expanded and stabilized following the 1984 flood. Flooding occurred again in August 1988. The 1988 year class was eliminated, and the abundance of all other size classes was reduced. The population recovered from the 1988 flood impacts by 1992. The relatively high, consistent flows in 1993 resulted in a strong year class and an increase in age 1 Gila trout in 1994 (USFWS 2003).

Population Narrative:

As of August 2019, there were 17 populations of Gila trout (Oncorhynchus gilae) inhabiting approximately 137.5 kilometers (km) (85.2 miles (mi)) of stream habitat. All known, remnant genetic lineages (Main Diamond Creek, South Diamond Creek, Whiskey Creek, Iron Creek and Spruce Creek) were represented by at least two wild populations. The five remnant lineages encompass the existing genetic diversity of the species, and each contributes significantly to it. Heterozygosity of all of the remnant lineages of Gila trout, with the exception of Iron Creek, has declined from 2002 to 2013. Loss of genetic diversity has been particularly acute in the Spruce Creek lineage. The Main Diamond and South Diamond lineages were relatively secure, with hatchery broodstock and production having been successfully developed and populations present in 9 of the 17 occupied streams. The current situation of the other three lineages, however, is less secure, and only one mixed-lineage population existed by August 2019. The remnant-lineage populations in Whiskey Creek and Spruce Creek were extirpated following large-scale, highseverity wildfire. At the beginning of 2019, populations of these lineages were present in only three other streams, and these streams supported only small populations. The Iron Creek lineage occurred in only two streams at the beginning of 2019, and those populations contained unique genetic variation. Resiliency of Gila trout is constrained by the patchy distribution and geographic isolation of cold-water streams, many of which are single-stream systems that are relatively small, throughout the species' historical range. Few, if any, extant populations of Gila trout are large enough to survive extremes in environmental conditions without experiencing a severe population bottleneck (drastic reduction in population size). Currently only the Mogollon and Willow creek drainages (where the South Diamond lineage has been established) have a dendritic (branching stream network) population structure, and even the largest single-stream systems where Gila trout have been repatriated (e.g., Black Canyon) have been subject to extirpations associated with environmental stochasticity. Recovery actions implemented to date have greatly improved redundancy by increasing the number of populations of Gila trout. However, spatial distribution of populations is constrained by the geographical distribution of currently suitable habitat for the species. (USFWS, 2021). As of April 2022, there were 23 populations of Gila trout (Oncorhynchus gilae) inhabiting approximately 210.8 kilometers (km) (131.0 miles (mi)) of stream habitat. All known, remnant genetic lineages (Main Diamond Creek, South Diamond Creek, Whiskey Creek, Iron Creek and Spruce Creek) were represented by at least three wild populations. These five remnant lineages encompass the existing genetic diversity of the species, and each contributes significantly to it. Heterozygosity of all the remnant lineages of Gila trout, with the exception of Iron Creek, has declined from 2002 to 2013. Loss of genetic diversity has been particularly acute in the Spruce Creek lineage. The Main Diamond and South Diamond lineages were relatively secure, with hatchery broodstock and production having been successfully developed in 10 of the 23 occupied streams. The current status of the other three lineages is less secure, with three mixed-lineage populations established by 2022. The remnant-lineage populations in Whiskey Creek and Spruce Creek were extirpated following large-scale, high-severity wildfire in 2012. Spruce Creek was restocked in 2018, bringing the total occupied streams to three, and the Whiskey Creek lineage is represented in four streams. The Iron Creek lineage occurred in three streams at the beginning of 2022, and those populations contained unique genetic variation. Resiliency of Gila trout is constrained by the patchy distribution and geographic isolation of cold-water streams, many of which are single-stream systems that are relatively small, throughout the species' historical range. Few extant populations of Gila trout are large enough to survive extremes in environmental conditions without experiencing a severe population bottleneck (drastic reduction in population size). Even the largest single-stream systems where Gila trout have been repatriated (e.g., Black Canyon) have been subject to extirpations associated with environmental stochasticity. Currently the Mogollon and Willow Creek drainages (where the South Diamond lineage has been established) and Whitewater Creek (mixed-lineage) have a dendritic (branching stream network) metapopulation structure. Recovery actions implemented to date have greatly improved redundancy by increasing the number of populations of Gila trout. However, spatial distribution of populations is constrained by the geographical distribution of currently suitable habitat for the species, due to both human-induced and natural factors (USFWS, 2022).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Changes in habitat suitability.
Response: Several, including altered stream flow volume and temperature.

Consequence: Decreased population numbers.
Narrative: In 1898, Gila trout was found in the upper Gila River drainage in New Mexico, from the headwaters downstream to the Mogollon Creek confluence. By 1915, the downstream limit in the Gila River had receded upstream to Sapillo Creek. By 1950, water temperature in the Gila River at Sapillo Creek was considered too warm to support any trout species. The causes of habitat degradation were not reported. However, extensive logging and grazing throughout the upper Gila River drainage likely resulted in changes in habitat characteristics, such as timing and duration of peak flows; length of perennially flowing stream channel; base flow discharge; water temperature; and sediment loading. Also, concentration of early logging impacts along stream bottoms may have resulted in long-term reduction of the availability of large, woody debris in the stream channel, which has been identified as an important component of habitat of Gila trout (USFWS 2003).

Stressor: Habitat destruction
Exposure: Catastrophic forest fire.
Response: Several, including altered stream flow volume and temperature.
Consequence: Decreased population numbers.
Narrative: High-severity forest fires have caused the extirpation of three populations of Gila trout. The population in Main Diamond Creek was lost in 1989, the population in Burnt Canyon and South Diamond Creek was lost to fire in 1995, and the population in Trail Canyon was extirpated in 1996. Severe forest fires capable of extirpating or decimating fish populations are a relatively recent phenomena, resulting from the cumulative effects of historical or ongoing overgrazing by domestic livestock, and fire suppression (USFWS 2003).

Stressor: Overutilization for recreational purposes
Exposure: Uncontrolled angling.
Response: Over utilized resource.
Consequence: Decreased population numbers.
Narrative: Historically, unregulated harvest of Gila trout likely contributed to the dramatically diminished distribution of the species by the 1960s. Streams depleted of native trout were then stocked with hatchery-raised, nonnative species to support recreational fishing. By the time regulations were implemented to limit the harvest of fish, the range of Gila trout had been reduced to several isolated headwater streams. Mortality of Gila trout from illegal angling may pose a major threat to some populations (USFWS 2003).

Stressor: Predation
Exposure: Nonnative competitors and predators.
Response: Predation from and competition with brown trout.
Consequence: Decreased population numbers.
Narrative: Brown trout (Salmo trutta), a nonnative salmonid introduced to the United States from Europe, are naturalized throughout the historical range of Gila trout. Brown trout are highly piscivorous and may severely depress populations of Gila trout. Populations of Gila trout may be able to withstand low levels of predation by brown trout. However, predation effects exerted over several consecutive years, coupled with population expansion of brown trout, may result in extirpation of Gila trout from a stream (USFWS 2003).

Stressor: Inadequacy of existing regulatory mechanisms
Exposure: Limited protection of species.

Response: Over utilized resource.
Consequence: Decreased population numbers.
Narrative: Prior to federal listing in 1967, Gila trout had no legal protection. Federal listing provided protection from take. In 1975, the state of New Mexico designated Gila trout as an endangered species, prohibiting take of the species without a scientific collecting permit (USFWS 2003).

Stressor: Hybridization with nonnative trout
Exposure: Introgressive hybridization with rainbow trout.
Response: Dilution of pure genetic strains.
Consequence: Decreased population numbers.
Narrative: Hybridization with rainbow trout (O. mykiss) is a major cause for the decline and continued imperilment of Gila trout. Stocking of rainbow trout within the historical range of Gila trout began in 1907. Although current stocking of rainbow trout is conducted only in stream segments that are not inhabited by Gila trout, rainbow trout have become naturalized throughout the range of Gila trout. Hybridization remains a prominent threat to Gila trout, as evidenced by the loss of previously presumed pure populations (Iron Creek and McKenna Creek) and the detection of recent introgression of rainbow trout genes in the Mogollon Creek population. Hybridization is a threat to Gila trout because it results in erosion and loss of the unique genetic identity of the species, which represents its evolutionary history and local adaptation to the environments it inhabits (USFWS 2003).

Recovery

Reclassification Criteria:
Recovery Priority Number: 8

Delisting Criteria:
At least 20 populations in the Gila River Recovery Unit are established within at least 150 km (93 mi.) of the stream (USFWS 2003).

At least 15 populations in the San Francisco River Recovery Unit are established within at least 80 km (50 mi.) of the stream (USFWS 2003).

At least four San Francisco-Gila River mixed-lineage populations are established within at least 40 km (25 mi.) of the stream (USFWS 2003).

A population will be considered established when it is self-sustaining, and capable of persisting under the range of variation in habitat conditions that occur in the restoration stream; and when the population is protected from immigration of nonnative trout. Naturally functioning stream habitat is characterized by unregulated stream flow, properly functioning riparian areas, watershed conditions that produce a natural hydrograph, and the absence of nonnative fishes. Recovery streams should exhibit these conditions or should be under management to restore these conditions. Restoration streams that are subject to livestock grazing will be managed to maintain healthy riparian vegetation and good watershed condition. Adequate riparian and watershed condition will be indicated by rates of infiltration, runoff, upland erosion, bank erosion, and sediment transport and storage that occur in naturally functioning systems (USFWS 2003).

Recovery Actions:

- Establish populations of Gila trout and ensure protection of known, nonhybridized genetic lineages in potential restoration streams or hatchery facility (USFWS 2003).
- Protect populations of Gila trout through regulations, including the Endangered Species Act; and through removal of nonnative trout within historical range of the species (USFWS 2003).
- Intensive management of livestock operations within the watershed to prevent overgrazing (USFWS 2003).
- Protection from catastrophic wildfires (USFWS 2003).
- Removal of nonnative trout (USFWS 2003).
- Establish hatchery stock for use to produce adequate numbers of fish for recovery actions, and to serve as short-term refugia to ensure the security of lineages (USFWS 2003).
- Conduct monitoring of populations and habitat to measure progress toward recovery, and to protect recovered populations from decline (USFWS 2003).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The Service has identified six actions that are needed aid in the recovery of Gila trout. The actions are: 1. Repatriate Gila trout to streams within its presumed historical range; 2. Establish and maintain captive propagation methods and conservation hatchery facilities in suitable locations; 3. Manage the presence of nonnative salmonid species in recovery streams in Arizona and New Mexico; 4. Monitor remnant and repatriated Gila trout populations within the Gila River drainage basin; 5. Conduct public education, involvement, and outreach in areas with an interest in Gila trout; 6. Develop and implement regulations to maintain sustainable Gila trout populations in recovery streams opened to sport fishing in Arizona and New Mexico. (USFWS, 2020)

Additional Threshold Information:

- Overwintering Habitat: Overwintering habitat is defined as areas used by Gila trout that afford shelter during periods of water temperature minima, generally from November through February. Pool habitat is recognized as an import component for overwinter survival of Gila trout. However, the relationships between pool depth and survival rate have not been elucidated. Essential elements of overwintering habitat are deep water with low current velocity and protective cover. Examples include deep pools with cover such as boulders or root wads, or deep beaver ponds. Access to larger main-stem habitats from headwater streams may be an important function of overwinter survival where a perennial surface water connection between streams exists. Similar to subadult and adult habitat, populations of Gila trout may be quite sensitive to impacts that result in reduced cover and pool depth. Creation of barriers to fish movement that may prevent fish from accessing overwintering habitat may also result in impacts to populations of Gila trout (USFWS 2003).
- Overwintering Habitat: Overwintering habitat is defined as areas used by Gila trout that afford shelter during periods of water temperature minima, generally from November through February. Pool habitat is recognized as an import component for overwinter survival of Gila trout. However, the relationships between pool depth and survival rate have not been elucidated. Essential elements of overwintering habitat are deep water with low current velocity and protective cover. Examples include deep pools with cover such as boulders or root wads, or deep beaver ponds. Access to larger main-stem habitats from headwater streams may be an important function of overwinter survival where a perennial surface water connection between streams exists. Similar to subadult and adult habitat, populations of Gila trout may be quite sensitive to impacts that result in reduced cover and

pool depth. Creation of barriers to fish movement that may prevent fish from accessing overwintering habitat may also result in impacts to populations of Gila trout (USFWS 2003).

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SPECIES ACCOUNT: *Percina antesella* (Amber darter)

Species Taxonomic and Listing Information

Listing Status: Endangered; 8/5/1985; Southeast Region (R4) (USFWS, 2015)

Physical Description

A small fish (darter). The length is 6 cm. (NatureServe, 2015)

Taxonomy

Not Available

Historical Range

The amber darter is endemic to the Coosa River basin. When it was listed in 1985, the fish was known to occur only in a 33.5-mile reach of the Conasauga River mainstem, from the Tibbs Bridge crossing, Murray County, Georgia, upstream to the TN Hwy 74 crossing, Polk County, Tennessee (USFWS, 2014).

Current Range

Range includes the Conasauga, Coosawattee, and Etowah rivers (Coosa River system), northwestern Georgia and extreme southeastern Tennessee (Page and Burr 2011): mainstem Etowah River upstream of Allatoona Reservoir (from near the mouth of Amicalola Creek downstream to Canton, Georgia), the lower portion of Sharp Mountain Creek (a tributary to the Etowah River in Cherokee County, the lower portion of Shoal Creek (above the area influenced by the Allatoona Reservoir; an approximately 55-km reach of the Conasauga River, from the vicinity of the U.S. 411 bridge in Polk County, Tennessee, to the vicinity of Browns Bridge Road outside of Dalton, Georgia (Murray and Whitfield counties); and the Coosawattee River, downstream of Carter's Lake Reservoir (single specimen collected in 2010 (Freeman et al. 2010). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/5/1985.

Legal Description

On August 5, 1985 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Percina antesella (Amber darter) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Tennessee and Georgia (50 FR 31597-31604).

The critical habitat designation for Percina antesella includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Percina antesella.

Critical Habitat Designation

The critical habitat designation for Percina antesella includes one CHU (approximately 33.5 river miles) in Polk and Bradley Counties, Tennessee and Murray and Whitfield Counties, Georgia (50 FR 31597-31604).

(1) Tennessee and Georgia: Conasauga River from the U.S. Route 411 bridge in Polk County, Tennessee. downstream approximately 33.5 miles through Bradley County. Tennessee and Murray and Whitfield Counties, Georgia, to the Tibbs Bridge Road bridge (Murray County Road 109 and Whitfield County Road 100).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (50 FR 31597-31604):

(1) Constituent elements include high quality water, riffle areas (free of silt) composed of sand, gravel, and cobble, which becomes vegetated primarily with Podostemum during the summer.

Life History

Feeding Narrative

Adult: Diet includes snails and immature aquatic insects (Etnier and Starnes 1993). Adults and immatures are invertivores (NatureServe, 2015). Larvae transform into benthic juveniles 15-30 days after hatching. By spring, one year old darters have grown to 1.75 inches, and to over 2 inches at 2 years (Etnier and Starnes 1993) (USFWS, 2014). Gastropods, insects (primarily Trichoptera and Ephemoptera) were found in amber darter stomachs (Freeman, 1983) (USFWS, 1986).

Reproduction Narrative

Adult: Spawning apparently occurs in late winter and early spring. Some may live up to about 4 years (Etnier and Starnes 1993).; Density is not more than 2-3/100 sq. m within any given shoal (1990 End. Sp. Tech. Bull. 15[2]:5). Spawning occurs probably in swift gravel shoal areas (Etnier and Starnes 1993) (NatureServe, 2015). Spawning individuals have been observed burying themselves in gravel, and females are known to bury their eggs in these sediments during spawning (B. Freeman, UGA, and M. Freeman, USGS, pers. comm.). Sexual maturity of some specimens occurs at slightly over one year’s growth, and all are mature at two years (USFWS, 2014).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Narrow to moderate (inferred from NatureServe, 2015)

Tolerance Ranges/Thresholds

Adult: Low to moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: Low to moderate (see dispersal/migration narrative)

Habitat Narrative

Adult: In Tennessee, this species is restricted to the main channel of the Conasauga River, where it occurs in flowing pools and deeper runs with clean substrates of sand and fine gravel with scattered boulders (Etnier and Starnes 1993). It has been found associated with vegetation in riffle areas in midsummer. Usually it is in cool, clear water up to 60 cm deep (usually 29-49 cm), with moderate to swift current (averaging around 7-27 cm/sec at substrate); it occurs in only a small percentage of shoals with these characteristics (Lee et al. 1980; 1990 End. Sp. Tech. Bull. 15[2]:5). The species is limited upstream from occupied sites probably by excessive stream gradient, downstream by heavy siltation (Matthews and Moseley 1990) and reservoir. Spawning occurs probably in swift gravel shoal areas (Etnier and Starnes 1993). Larvae may inhabit different areas and may even drift with the current (Freeman and Freeman 1994). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). Freeman (1983) observed the amber darter using Podostemon vegetation for feeding and cover during the summer (USFWS, 1986).

Dispersal/Migration

Motility/Mobility

Adult: Moderate (inferred from USFWS, 2014)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Moderate (inferred from USFWS, 2014)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Larvae may inhabit different areas and may even drift with the current (Freeman and Freeman 1994) (NatureServe, 2015). Benthic juveniles move upstream to suitable habitat (USFWS, 2014).

Population Information and Trends

Population Trends:

Not available

Species Trends:

Decreasing (USFWS, 2014)

Resiliency:

Count data from surveys over almost two decades indicate numbers of amber darters in both populations are declining, with estimated losses of 12% and 9% annually in the Conasauga and Etowah Rivers. Occupancy of shoals has decreased in the Conasauga, and fish have been extirpated or greatly reduced in abundance in the lower reaches of the historic range in both systems. Declining populations suggest the species, currently, has low resiliency to environmental or demographic stochastic events and/or existing anthropogenic-related stressors (USFWS, 2019).

Representation:

Two declining populations genetically-isolated by Lake Allatoona. Low to Moderate Representation (USFWS, 2019).

Redundancy:

Only two populations are known historically, and neither appears resilient to stochastic or catastrophic events and/or to current anthropogenic stressors. Redundancy low (USFWS, 2019).

Number of Populations:

2 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Adaptability:

Low (inferred from NatureServe, 2015)

Population Narrative:

Total adult population size is unknown but relatively small. Based on snorkeling and seining observations in the 1980s and 1990s, Freeman (1991, 1995) reported that amber darters persist in low population densities in the Conasauga River. Freeman et al. (2010) noted the relatively low abundance of this species. Occurs only in small sections of two rivers, only one of which supports a healthy population. The range extent is 400 - 2,000 square miles (NatureServe, 2015). The species status is decreasing in both the Etowah and Conasauga basins. Levels of genetic diversity are considerably higher in the Conasauga population, and little genetic differentiation between shoals within either river was observed. These results indicate amber darters in the Etowah and Conasauga Rivers are somewhat genetically different but represent a single species (Freeman et al. 2012) (USFWS, 2014).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Land use in the upper basin has changed little over the past decade -- the dominant land covers remain agriculture and forestry, and the headwaters of the basin are protected by extensive US Forest Service land. Low density urban development has increased throughout the basin, but dense urban sprawl is concentrated downstream of known areas of high aquatic diversity. The only major land use changes we identified in the basin over the past decade were (1) a largescale shift to use of Roundup-ready seed for major row-crop products and (2) greater use of poultry litter to fertilize pastures and row crops (Cindy Askew, NRCS, pers. comm., June 2008). These changes in land use could have significant impact on Conasauga water quality because agricultural fields in the river's floodplain above Dalton are heavily ditched (Fig. 11),

facilitating transport of agricultural chemicals into stream systems. The Nature Conservancy located hundreds of agricultural ditches in a 2008 survey of a 40-mile reach of the upper basin (Kathleen Owens, TNC, pers. comm. Feb. 2009). These ditches tend to bypass standard agricultural water quality best management practices, like riparian buffers or grass filter strips, and convey polluted runoff directly into the Conasauga River and its tributaries

Stressor: Stochastic events (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Amber darters in the Conasauga are limited to the river's mainstem, generally occurring in small numbers in shoal habitat. The limited distribution makes this species vulnerable to localized extinction over much of their ranges in the event of human-caused toxic chemical spills, catastrophic natural events like flood or severe drought, genetic drift, and other stochastic events (USFWS, 2014).

Stressor: Climate change (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: In the Southeast through the 21st century, climate models project that average annual temperatures will increase, cold days will become less frequent, the freeze-free season will lengthen by up to a month, temperatures exceeding 95 degrees will increase, heat waves will become longer, sea levels will rise an average of 3 feet, the number of category 3 to category 5 hurricanes will increase, and air quality will decline (Ingram et al. 2013). Aquatic systems will be impacted by increasing water temperatures, decreasing dissolved oxygen levels, altered streamflow patterns, increased demand for water storage and conveyance structures, and increasing toxicity of pollutants (Ficke 2007, Rahel and Olden 2007). Reduced spring/summer rainfall, coupled with increased evapotransporation and water demand (because of population growth), could lead to local extirpations if streams dry out more frequently (Ingram et al. 2013) (USFWS, 2014).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1.Through protection of the existing Conasauga River population and by introductions or expansion of the species in the Etowah River, or discovery of an additional population, there exist viable populations in two rivers (USFWS, 2014).

2. Studies of the fish's biological and ecological requirements have been completed and management strategies have been developed and implemented to ensure the species no longer is likely to become extinct in the foreseeable future (USFWS, 2014).

Recovery Actions:

- Preserve Conasauga River populations and presently used habitat of the amber darter (USFWS, 1986).
- Search for additional populations and/or habitats suitable for reintroduction efforts (USFWS, 1986).
- Determine the feasibility of reestablishing the amber darter back into its historic habitat in the Etowah River and other suitable stream reaches that are determined to have been historic habitats (USFWS, 1986).
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as any newly discovered, introduced, or expanding populations (USFWS, 1986).
- Annually assess overall success of the recovery program and recommend action (changes in recovery objectives, delist, continue to protect, implement new measures, other studies, etc.) (USFWS, 1986).
- Work with local governments in the Etowah River basin to develop a new HCP(s) or other basin wide management plan to protect aquatic resources (USFWS, 2014).
- Develop a conservation banking program in the Etowah River basin to compensate for loss of aquatic habitats that support Etowah, Cherokee, and amber darters (USFWS, 2014).
- Work to establish a Conasauga River conservation area to protect high priority amber darter reaches (USFWS, 2014).
- Fund annual long-term monitoring of these species in the Etowah and Conasauga basins (USFWS, 2014).
- Develop a baseline database on stream geomorphic characteristics in high quality Cherokee darter streams. Use these data to revise stream restoration methods commonly used in the basin to ensure development of habitat for benthic shoal-dwelling fishes is a primary restoration project component (where applicable) (USFWS, 2014).
- Complete the chemical profile of the Conasauga. If agricultural contaminants appear to be a major stressor on amber darters and other protected and rare species in the Conasauga, work with NRCS to reduce input into the River (USFWS, 2014).
- Complete the study to evaluate intersex fish incidence in the Conasauga. Concurrently, evaluate the effect of environmental estrogens on public health and communicate these results to GEPD and local governments (USFWS, 2014).
- Develop and implement programs and materials to educate government officials and the public on the need and benefits of ecosystem management and to involve them in watershed stewardship for these and other aquatic species (USFWS, 2014).
- Work with GEPD and EPA to incorporate listed species' review into NPDES point-source and construction permit review (USFWS, 2014).
- Continue to hold periodic Conasauga and/or Coosa Summits to bring together researchers, land managers, environmental groups, local government officials, and others to discuss recent Conasauga/Coosa research results, new threats, and needed management actions. Continue to meet in smaller committees, as needed, to discuss management actions to address stressors (USFWS, 2014).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Assessment and monitoring of current and potential suitable habitat in the Conasauga, Etowah, and Coosawattee River basins • Investigating species' demographics and threat sensitivity • Protecting and restoring key parcels via land acquisition, conservation agreements, and conservation easements • Restoring shoal habitat in the Conasauga and Etowah basins to promote adequate substrate, flows, and water quality, moderate spring flows, and increase shoal habitat connectivity • Developing controlled captive propagation and reintroduction plans for the species • Monitoring and reducing sources of sedimentation, nutrients, toxins, and contaminants impacting amber darter habitat in the Conasauga and Etowah basins (e.g., nutrient management plans and trading programs, sediment trapping projects, livestock exclusion, subsurface fertilizer application, streamside buffers, streamside fencing, continuous no-till, cover crops) • Develop and implement local/county/state policy to regulate stormwater management, nutrient management, and earth-moving activities, establishing stormwater utility fees, and other actions to address urban, agricultural, and industrial stressors in the Conasauga and Etowah basins • Develop and implement state and local government policy and regulations to improve protection of the fish and its habitat and enhance enforcement of such policies and regulation (USFWS, 2021)

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SPECIES ACCOUNT: *Percina aurolineata* (Goldline darter)

Species Taxonomic and Listing Information

Listing Status: Threatened; 4/22/1992; Southeast Region (R4) (USFWS, 2015)

Physical Description

A slender, medium-sized fish, the goldline darter is about 75 mm (3 in) long with brownish red and amber dorsolateral (on the upper side) stripes. It differs from other members ofthe subgenus Hadropterus in the color pattern ofits back, which is pale to dusky. (USFWS, 2000).

Taxonomy

In the Percidae (perches and darters) family in order Perciformes (NatureServe, 2015)

Historical Range

Goldline darters historically existed in approximately 78.9 km (49 mi) of the Cahaba River and almost 11.3 km (7 mi) of the Little Cahaba River (Boschung and Mayden 2004; USFWS 2000; Stiles 1990, 1978). Thus, there has been an overall reduction in the Cahaba River total range of about 35km (22 mi) when current and historical ranges are compared. (NatureServe, 2015)

Current Range

Range includes the Coosawattee River (Coosa River system), Georgia, and Cahaba River system (Cahaba River, Little Cahaba River, and Schultz Creek; Mobile Bay drainage), Alabama (Boschung and Mayden 2004, Page and Burr 2011).Formerly this species occurred in 79 km of the Cahaba River, almost 11 km of the Little Cahaba River, and in Coosawattee River system; it survives in fragmented populations in the Coosawattee River, in about 11 km of the Little Cahaba River, and in 43 km of the Cahaba River (End. Sp. Tech. Bull. 16[5]:7-8). Rare and localized. Recent records are from the Cahaba River main channel between Piper Bridge (County Hwy 24) and Centreville and the lower reach of Little Cahaba River below Bulldog Bend (County Hwy 65), Bibb County (Pierson, pers. comm., 1997). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Six specimens contained insect larvae, mostly chironomids (Lee et al. 1980). Adults and immatures are invertivores (NatureServe, 2015). Embryonic and early larval development is rapid (Shute, 2003) (USFWS, 2015).

Reproduction Narrative

Adult: Boschung and Mayden (2004) reported spawning in the wild from early April to July. Shute (2003) found that eggs were adhesive when recently spawned, attaching to sand and debris (USFWS, 2015).

Geographic or Habitat Restraints or Barriers

Adult: Waterfalls, dams, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (see dispersal/migration narrative)

Habitat Narrative

Adult: Habitat includes fast rocky runs of small to medium rivers (Page and Burr 2011); main channels in areas of white-water rapids to three or more feet deep, and substrates of bedrock, boulders, rubble and gravel. Podostemum and Justicia characteristically are present. (Lee et al. 1980). Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). The goldline darter inhabits mainly fifth order streams (Freeman and Troth 1999), with width of 15 m to 60 m (49 ft. to 197 ft.) (Suttkus and Ramsey 1967), in moderate to swift currents from 11 cm/s (4.3 in/s) to 73 cm/s (28.7in/s), and in depths of 30 cm to 0.6m (11.8 in to 1.96 ft.) or greater (USFWS, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Not available

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Not available

Dispersal/Migration Narrative

Adult: This species is non-migratory. Data on dispersal and other movements generally are not available (NatureServe, 2015).

Population Information and Trends

Species Trends:

Stable or increasing (inferred from USFWS, 2015)

Number of Populations:

1 - 20 (NatureServe, 2015)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

In Alabama, this species occupies only about half of its historical range (Boschung and Mayden 2004). Total adult population size is unknown but may not exceed 10,000. Number of occurrences has not been determined using standardized criteria. Possibly there are 8-10 occurrences in the main channels of Cahaba and Little Cahaba rivers, plus additional occurrences in the Coosawattee River. The range extent is 400 - 2,000 square miles (NatureServe, 2015). The species status is slightly improved; site specific data and minor improvements in habitat indicate some improvements in status over the last 5 years. Within the Cahaba River system, genetics indicate that this is a single panmictic population (no mating restrictions in the population; all individuals are potential recombination partners) with limited or no restrictions to gene flow (Powers 2013) (USFWS, 2015). Goldline darters are currently restricted to small portions of the Cahaba River system and the upper Coosawattee Reiver. The species' clustered distribution and small population sizes makes it vulnerable to random natural or anthropogenic events that negatively impact habitat quality and quantity and fragmentation prevents natural recolonization of many reaches of river/stream after extirpation events. Protection and enhancement of water quality and quantity, especially during low flows and droughts, is necessary for the species' survival in both the Cahaba and upper Coosawattee rivers. Because of on-going threats throughout the species range, the species' limited distribution and isolation increasing risks of catastrophic events and genetic impairments, the goldline darter continues to meet the definition of a threatened species under the Act. (USFWS, 2021)

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2015)
Exposure:
Response:
Consequence:
Narrative: Studies in general show that increased urbanization generally leads to declining water quality in streams and fish assemblages (Onorato et al. 2000, Anderson et al. 1995, Waters 1995, Weaver and Garman 1994). In particular, Honavar (2003) observed a negative correlation between water quality (sedimentation) and percent relative abundance of crevice spawning minnows and darters in the Cahaba River system. Impairment of aquatic life in the Cahaba River has been related to nutrient over enrichment compounded by sedimentation and extremes in prevailing hydrologic patterns as reflected in decreased diurnal dissolved oxygen fluctuations at Piper Bridge (the upper mid-range of the species). The species is threatened in Georgia by habitat loss and population fragmentation associated with Carters Lake and water quality impacts associated with poor land use (Powers 2008). Development is an emerging threat to the Coosawattee watershed where Gilmer County has had a 24% increase of population size between 2000 and 2009, and the Coosawattee River basin has had a corresponding 3.5% increase in constructed or built on land and a 2.4% decrease in forest cover (Natural Resource Spatial Analysis Lab 2012 in Albanese et al. 2013). Flow in the lower Coosawattee River is regulated by releases from Carter Dam, potentially affecting the species, which is considered extirpated from this reach (USFWS, 2015).

Stressor: Population fragmentation (USFWS, 2015)
Exposure:
Response:

Consequence:
Narrative: The concern, at the time of listing, that the increased fragmentation of the goldline darter habitat and isolating of existing populations would continue to make the species more susceptible to environmental changes and decreased genetic diversity is still accurate. Studies show that increased urbanization leads to declining water quality in streams and fish assemblages (Onorato et al. 2000, Anderson et al. 1995, Weaver and Garman, 1994) which have resulted in producing several isolated goldline darter populations. Isolation makes the populations more susceptible to environmental changes resulting in decreased genetic diversity and reproduction. In Georgia, Carters Lake, a 1,295 ha (3,200 acre) impoundment fragments and blocks fish passage of the species at the junction of the Blue Ridge and the Ridge and Valley physiographic provinces. An additional dam and fish passage obstruction, occurs downstream of Carters lake dam and fragments Talking Rock Creek from the Ridge and Valley portion of the Coosawattee River (Albanese et al. 2013). Goldline darters may be more sensitive to isolation (e.g., perched culverts, dams) than species comprised of demographically independent populations (Albanese et al 2013) (USFWS, 2015).

Recovery

Reclassification Criteria:
Not available

Delisting Criteria:
1. The known populations of the species (goldline darter) are shown to be stable or increasing for a period of at least 5 years (USFWS, 2015).

2. There has been a demonstrated trend in water quality improvement in the reach of the Cahaba River occupied by this fish. (Note that in the recovery plan for the species, there is no mention of the Georgia populations) (USFWS, 2015).

3. Community developed watershed plans are implemented to protect and monitor water and habitat quality in all occupied watersheds (USFWS, 2015).

Recovery Actions:
- Protect habitat integrity and quality (USFWS, 2000).
- Consider options for river and stream mitigation strategies that give high priority to avoidance and restoration (USFWS, 2000).
- Promote voluntary stewardship to reduce nonpoint pollution from private land use (USFWS, 2000).
- Encourage and support community based watershed stewardship planning and action (USFWS, 2000).
- Develop and implement public education programs and materials defining ecosystem management and watershed stewardship responsibilities (USFWS, 2000).
- Conduct basic research on endemic aquatic species and apply the results of this research toward management and protection (USFWS, 2000).
- Develop and implement technology for maintaining and propagating endemic species in captivity (USFWS, 2000).
- Reintroduce aquatic species into restored habitats, as appropriate (USFWS, 2000).

- Monitor listed species population levels and distribution and review ecosystem management strategy (USFWS, 2000).
- Coordinate ecosystem management actions and species recovery efforts (USFWS, 2000).
- Focus monitoring on the areas of high habitat suitability identified in Georgia and extending this model to the Cahaba River population (USFWS, 2015).
- Initiate long-term monitoring and PVA of the species that includes age/sex information, natality and mortality, larval and juvenile fish life stages (USFWS, 2015).
- Continue surveys of the Cahaba River and upper Coosa River basins with suitable habitat that may have the chance of containing goldline darters. Use new technology in surveying specifically environmental DNA survey methods (USFWS, 2015).
- Work to obtain protection for riverine and tributary buffering on privately owned lands specifically by forming relationships with landowners and working with conservation groups, state, county and town governments (USFWS, 2015).
- Establish best management and conservation practices to improve water quality and water quantity issues by reducing stormwater runoff, sediment and eutrophication. Protect through cooperative agreement, conservation easement, fee title purchase or other means to guarantee safeguards to the water quality, especially turbidity, water quantity, geomorphology, hydrology and other aspects of the habitat and natural history of the species (USFWS, 2015).
- Work to enforce existing regulations and land management laws should be enforced along with implementation of existing conservation and water quality and water quantity plans (USFWS, 2015).
- Continue developing techniques for propagation and husbandry of the species (USFWS, 2015).
- Revise and expand the recovery plan as a stand-alone document to reflect new information like the Georgia populations and refine criteria (USFWS, 2015).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS • Conduct high resolution genetic analyses to confirm or refute hypothesized source-sink population dynamics. o Identify source populations and implement protection plans targeting these populations. o Estimate effective population size. • Establish long-term monitoring of the Cahaba and Coosawattee River basins. • Develop a spatial model of suitable habitat for the species in the Cahaba River to direct surveys and prioritize management and restoration efforts. • Collect demographic data required to conduct population viability analysis including age, sex, natality, and mortality of larval, juvenile, and adult life stages. • Survey the Cahaba and upper Coosawattee river watersheds to identify and prioritize culverts and other fish passage barriers for removal. • Use environmental DNA (eDNA) survey methods to identify habitats that may support the species in low abundances that make them hard to detect. • Develop an updated species recovery plan to reflect new information and refine criteria. • Support protection and restoration of riverine buffers on privately-owned lands, by forming relationships with landowners and working with conservation groups, local and state governments. • Develop and implement best management practices for improving water quality and quantity, by reducing stormwater runoff, sediment loading, and eutrophication. Initiate cooperative agreement, conservation easement, fee title purchase or other means to guarantee safeguards to protect water quality. Of special concern are turbidity, water quantity, sedimentation, geomorphology, hydrology and other aspects of habitat quality that may impact the species. • Implement new, and enforce existing, conservation, water quality, and land management laws and regulations that promote the improvement of habitat quality for the species. • Develop a captive propagation plan for the species. (USFWS, 2021)

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SPECIES ACCOUNT: *Percina aurora* (Pearl darter)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

The Pearl darter (Percina aurora) is a small percid fish with a blunt snout, horizontal mouth, and large eyes situated high on the head, and a medial black caudal spot at the base of the caudal fin (Ross 2001, p.498). The Pearl darter was described in 1994 (Suttkus et al. 1994, pp.16-17). Previously known as Percina sp. 3 and the Pearl River channel darter (Ross et al. 1989, p. 25), the Pearl darter belongs to the subgenus Cottogaster and is closely allied to the channel darter (P. copelandi). The Pearl darter is distinguished from the channel darter by its larger body size, lack of tubercles and heavy pigmentation of breeding males, high number of marginal spines on the modified belly scales of breeding males, and fully scaled cheeks. Breeding males have two dark bands across the spinous dorsal fin, a broad, diffuse, dusky marginal band, and a pronounced dark band across the fin near its base. Breeding females are devoid of pigmentation on the ventral surface of head and body. The Pearl darter reaches a maximum standard length of 57 millimeters (mm) (2.28 inches (in.)) in females and 64 mm (2.56 in.) in males (Suttkus et al. 1994, p. 16).

Taxonomy

Percina aurora Suttkus and Thompson 1994 in Suttkus et al. 1994b:15 (type locale: Strong River, Simpson County, Mississippi (Ross 2001, p.500).

Historical Range

The Pearl darter is historically known only from localized sites within the Pearl and Pascagoula River drainages in Mississippi and Louisiana. Examination of site records of museum fish collections from the Pearl River drainage (Suttkus et al. 1994, pp. 17-19) suggest that the darter once inhabited the large tributaries and main channel habitats from St. Tammany Parish, Louisiana, to Simpson County, Mississippi. This includes approximately 154.5 km (96 river miles) of the Pearl River, 16.1 km (10 river miles) of the Strong River, and 51.5 km (32 river miles) of the Bogue Chitto River. Even before its description in 1994, the Pearl darter was rare and of conservation concern (Deacon et al. 1979, p. 42) because it was uncommon, infrequently collected, and occurred in low numbers (Bart and Piller 1997, p. 1). The Pearl darter was collected from only 14 percent of 716 fish collections from site-specific locations within the Pearl River drainage despite annual collection efforts by Suttkus from 1958 to 1973 (compiled from Bart and Suttkus 1996, pp. 3-4, Suttkus et al. 1994, p. 19). No Pearl darters have been collected in the Pearl River drainage since 1973, even though Suttkus has made 64 fish collections over the last 25 years from the Pearl River (Bart and Piller 1997, p. 1). Recently Schaefer and Mickle (2011, p. 10)) located and sampled putative Pearl darter habitat in the upper reaches of the Pearl River (above the reservoir). Even though fishes similar to those collected with the Pearl darter in the Pascagoula drainage were found, there is no evidence that the Pearl darter were ever found in the upper Pearl River system. Suttkus et al. (1994, p. 19) attributed the loss of the Pearl darter in the Pearl River to increasing sedimentation from habitat modification caused by removal of riparian vegetation and extensive cultivation near the rivers edge.

Current Range

Since 1983, Pearl darters are found only in scattered sites within approximately 231.7 km (144 mi) of the Pascagoula drainage, including the Pascagoula, Chickasawhay, Chunky, Leaf and Bouie Rivers and Okatoma and Black Creeks, and is considered extirpated from the Pearl River drainage. This has resulted in a decrease of range of approximately 55 percent (compiled from Bart and Piller 1997, pp. 3-10; Ross 2001, p. 499; Slack et al. 2005, pp. 5-10). Bart and Piller (1997, p. 3) made 27 ancillary collections in 1996 and 1997 from the Pascagoula drainage and collected only 10 Pearl darters at four sites. Three specimens were collected in the Leaf River at Estabutchie in the spring of 1998, whereas, in December 1998, no Pearl darters were found in the upper reaches of the Leaf River between Estabutchie and north Hattiesburg (Bart and Ross 1998, pers. comm.). Slack et al. (2005, p. 5) sampled for Pearl darters in the Leaf and Chickasawhay Rivers from their confluence with Pascagoula River up river to the communities of Enterprise and Hebron. Four-hundred and seven Pearl darters were counted: 66% from the Chickasawhay and 34% from the Leaf Rivers. This extended the upstream range on the Leaf River 41.5 km (25.8 mi). Slack et al. (2002, p. 15) found Pearl darters in the Pascagoula River at the confluence with Big Black Creek (Dead Lake) and in various locations 22 km (13.7 mi) downstream of Dead Lake. On going survey work has indicated the species is still found in these sites (Jake Schaeffer, pers comm. 2013). The Big Black Creek site was the locality where Hildebrand collected Pearl darters in 1933 (Suttkus et al. 1994, p. 16). No Pearl darters were found in selected sites of the Chunky River in 1995 and 1997 (Bart 1999, pers. comm.). Suttkus et al. (1994, p. 17) speculated that portions of the Leaf River and possibly the lower Black Creek might continue to support reproducing populations even though no recent collecting attempts had been made.

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Legal Description

We, the U.S. Fish and Wildlife Service (Service), designate critical habitat for the pearl darter (Percina aurora) under the Endangered Species Act of 1973 (Act), as amended. In total, approximately 524 river miles (843 river kilometers) in Clarke, Covington, Forrest, George, Green, Lauderdale, Jackson, Jones, Newton, Perry, Simpson, Stone, and Wayne Counties, Mississippi, fall within the boundaries of the critical habitat designation. The effect of this regulation is to designate critical habitat for the pearl darter under the Act.

Critical Habitat Designation

Critical habitat units are depicted for Clark, Covington, Forrest, George, Greene, Jackson, Jones, Lauderdale, Newton, Perry, Simpson, Stone, and Wayne Counties, Mississippi.

Unit 1: Pascagoula River drainage, Clarke, Covington, Forrest, George, Greene, Lauderdale, Jackson, Jones, Newton, Perry, Stone, and Wayne Counties, Mississippi. (i) Unit 1 consists of 494 river miles (mi) (794 river kilometers (km)) of connected river and stream channels within the Pascagoula River drainage, including: (A) The Pascagoula River from its confluence with the West Pascagoula River in Jackson County, upstream 63 mi (102 km) to the confluence of the Leaf and Chickasawhay Rivers in George County; (B) The Big Black/Black Creek from its confluence with the Pascagoula River in Jackson County, upstream 80 mi (129 km) to U.S. Highway 49 Bridge in Forrest County; (C) The Chickasawhay River from its confluence with the Leaf River just north of Enterprise, Clarke County, upstream 160 mi (257 km) to the confluence of Okatibbee Creek and Chunky River in Clarke County; (D) The Chunky River from its confluence with Okatibbee Creek in Clarke County, upstream 28 mi (45 km) to the third (most upstream) Highway 80 Crossing in Newton County; (E) The Leaf River from its confluence with the Chickasawhay River in George County, upstream 119 mi (192 km) to the bridge crossing at U.S. Highway 84 in Covington County; (F) The Bouie River from its confluence with the Leaf River, upstream 15 mi (24 km) to the confluence of Okatoma Creek, in Forrest County; and (G) The Okatoma Creek from its confluence with the Bouie River in Forrest County, upstream 28 mi (45 km) to the bridge crossing at U.S. Highway 84 in Covington County. (ii) The channel borders (and therefore the stream channel bottoms) in Unit 1 are generally privately owned agricultural or silvicultural lands with the exception of 76 mi (122 km) of the Pascagoula River channel border owned and managed by the Mississippi Department of Wildlife, Fisheries, and Parks, and 45 mi (72 km) owned by the U.S. Forest Service.

Unit 2: Strong River, Simpson County, Mississippi. (i) Unit 2 consists of approximately 30 mi (49 km) of the Strong River channel from its confluence with the Pearl River, upstream to U.S. Highway 49 in Simpson County. (ii) The channel borders (and therefore the stream channel bottoms) in this unit are generally privately owned agricultural or silvicultural lands with the exception of a short channel reach (0.39 mi (0.63 km)) owned and managed by the Simpson County Park Commission.

Primary Constituent Elements/Physical or Biological Features

Within these areas, the physical or biological features essential to the conservation of pearl darter consist of the following components:

(i) Unobstructed and stable stream and river channels with: (A) Connected sequences of channel runs and bends associated with pools and scour holes; and (B) Bottom substrates consisting of fine and coarse sand, silt, loose clay, coarse gravel, fine and coarse particulate organic matter, or woody debris.

(ii) A natural flow regime necessary to maintain instream habitats and their connectivity.

(iii) Water quality conditions, including cool to warm water temperatures (8 to 30 °C (46.4 to 86.0 °F)), high dissolved oxygen (5.8 to 9.3 mg/l), slightly acidic to basic pH (6.3 to 7.6), and low levels of pollutants and nutrients meeting the current State of Mississippi criteria, as necessary to maintain natural physiological processes for normal behavior, growth, and viability of all life stages of the species.

(iv) Presence of a prey base of small aquatic macroinvertebrates, including larval mayflies, larval caddisflies, larval black flies, ostracods (crustaceans), chironomids (midges), and gastropods (snails).

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features which are essential to the conservation of the species and which may require special management considerations or protection. The pearl darter faces threats from water quality degradation from point and non-point source pollution, discharges from municipalities, and geomorphological changes to its channel habitats (82 FR 43885, September 20, 2017, pp. 43888– 43893). The features essential to the conservation of this species may require special management considerations or protection to reduce the following threats: (1) Actions that alter the minimum or existing flow regime, including impoundment, channelization, or water diversion; (2) actions that significantly alter water chemistry or temperature by the release of chemicals, biological pollutants, or heated effluents into the surface water or connected groundwater at a point or non-point source; and (3) actions that significantly alter channel morphology or geometry, including channelization, impoundment, road and bridge construction, or instream mining. Examples of special management actions that would minimize or ameliorate threats to the pearl darter include: (a) Restoration and protection of riparian corridors; (b) implementation of best management practices to minimize erosion (such as State and industry best management practices for road construction, forest management, or mining activities); (c) stream bank restoration projects; (d) private landowner programs to promote watershed and soil conservation (such as the U.S. Department of Agriculture’s Farm Bill and the Service’s Private Lands programs); (e) implementation of best management practices for storm water; and (f) upgrades to industrial and municipal treatment facilities to improve water quality in effluents

Life History

Feeding Narrative

Adult: Chironomids (non-biting midges) and small crustaceans are the most important food items (Kuehne and Barbour 1983, p. 49).

Reproduction Narrative

Adult: Suttkus et al. (1994, p. 19) found Pearl darters spawning in the Pearl and Strong Rivers (Mississippi) during March and April in 1969. Collection data indicated that the species probably spawned in various locations of the Pearl River main stem and upper reaches of the middle Bogue Chitto River. In fish samples from the Pearl River, young-of-the year Pearl darters were collected in June. Females were sexually mature at 39 mm (1.56 in) standard length (SL), while males matured at 42 mm (1.68 in) SL. Five breeding males were collected from the Leaf River (Pascagoula system, Mississippi) during May in shallow water (15 cm (5.85 in)) over firm gravel and cobble in mid channel with a water temperature of 21°Celsius (69.8 °Fahrenheit) (Bart and Piller 1997, p. 9). Most Pearl darters mature in one year. Little information exists on the life history attributes or size and growth patterns of pearl darter. Maximum reported sizes of 64 mm (2.5 in) and 57 mm (2.2 in) SL for males and females, respectively, from the Pearl River drainage have been reported (Suttkus et al. 1994, pp. 13–20). Similarly, the largest individual taken from the Pascagoula River drainage was a 64 mm (2.5 in) SL male (Bouie River; Service 2021, unpublished data), and 71 collected individuals (7.5%) have been greater than 50 mm (1.9 in) SL. Length frequencies indicate the species lives up to 3 years in the wild (Bart et al. 2001, p. 14–15; Clark et al. 2018, p. 107); however, some individuals have survived in captivity at the Private John Allen National Fish Hatchery for more than four years (USFWS, 2023).

Geographic or Habitat Restraints or Barriers

Adult: impoundments and deep pools

Spatial Arrangements of the Population

Adult: clumped according to suitable habitat

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: Not applicable

Habitat Narrative

Adult: The pearl darter (Percina aurora) is a small bottom-dwelling freshwater fish that inhabits rivers and large creeks in the Pascagoula River drainage in Mississippi and historically the Pearl River drainage in Mississippi and Louisiana (USFWS, 2023). Little is known about the specific habitat requirements of this species. Pearl darters have been collected from gravel riffles and rock outcrops; deep runs over gravel and sand pools below shallow riffles; swift (90 centimeters per second (35.1 in per second)), shallow water over firm gravel and cobble in mid-river channels; and swift water near brush piles. Slack et al. (2002, p.10) found Pearl darters associated with scour holes on the inside bend of the river downstream from point bars; and substrata primarily of coarse sand with accumulation of detritus in troughs perpendicular to the shore line. A single post-spawning individual was collected in a deep, sluggish run over silty sand (Bart and Piller 1997, p.10). The Pearl darter is believed to have comparable habitat requirements to the channel darter (Suttkus et al. 1994, p.13). Habitat use of the Pearl darter is centered on deeper runs and pools with larger substrate particle size (Schofield et al. 1999, p. 1). The channel darter generally inhabits rivers and large creeks in areas of moderate current, usually over sand and gravel substrates found at the lower ends of riffles or at the edges of deep channels. Seasonally, channel darters move into the slower current of pools to use the scattered rubble as spawning sites (Kuehne and Barbour 1983, p. 49). Channel darters typically avoid deep sluggish pools, headwater creeks, and lacustrine/palustrine environments (Burr and Warren 1986, p. 334) with insufficient current to maintain a bottom of sand or sand mixed with gravel and rock (Page 1983, p. 45). Channel darters most often remain at depths approaching 1 meter (3.28 feet) during the day but move to shallow water at night (Kuehne and Barbour 1983, p. 49).

Dispersal/Migration

Motility/Mobility

Adult: Mobile

Migratory vs Non-migratory vs Seasonal Movements

Adult: non-migratory; seasonal movement to find suitable breeding habitat

Dispersal

Adult: moderate

Immigration/Emigration

Adult: No; habitat is too fragmented.

Dependency on Other Individuals or Species for Dispersal

Adult: Not applicable

Dispersal/Migration Narrative

Adult: Sub-adult Pearl darters may migrate up stream during the fall and winter to spawn in suitable gravel reaches. Elevated river discharge during the spring aids in downstream dispersal of young of the year (Bart et al. 2001, p.14; Ross et al. 2000, p. 11).

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Resiliency:

We assessed current resilience as a function of two population factors (frequency of occurrence and catch per unit effort) and three habitat factors (water quality/land use, protected areas, and reservoirs/channelization). Based on analysis of these factors, two units with moderate resilience, two units with moderate-high resilience, and three units with high resilience in the Pascagoula River drainage (Figure EX.1) and currently contribute to the species viability. However, the four resilience units in the Pearl River drainage do not contribute to the viability of the species as the species is no longer found in the drainage (USFWS, 2023).

Representation:

We assessed current representation as a function of the core attributes from Thurman et al. (2020) that assess the overall adaptive capacity of the species. Of particular note in the contribution to adaptive capacity were genetic diversity and unique habitats occupied by the species. Pearl darter displays limited population genetic structure, where the populations throughout the Pascagoula River drainage are relatively genetically homogeneous but do have some allelic diversity throughout the drainage (Schaefer et al. 2020, p. 14–16). We do not know the genetic contribution of the Pearl populations because the species is extirpated from the drainage. Additionally, we noted unique habitat occupied by the species based on river size/class throughout the current range in the Pascagoula River drainage. Overall, the species does display some levels of adaptive capacity, or representation, and is thus capable of adapting to changes in its environment (USFWS, 2023).

Redundancy:

We assessed current redundancy as a function of the distribution of moderate to highly resilient units. The seven currently occupied resilience units of the species are distributed relatively widely throughout the Pascagoula River drainage and all seven units have moderate or better resilience. However, since the species is no longer found in the Pearl River drainage, there is no redundancy within the Pearl River drainage and the distribution of the low resilient units do not contribute to viability of the species. Overall, the species has redundancy for only one of its two populations occupying one of two historical drainages. The extirpation of the species from the Pearl River drainage suggests the species is prone to succumbing to catastrophic events within a river system, likely due to anthropogenic causes. Thus, even though there is redundancy of the resiliency units in the Pascagoula, the species could be considered vulnerable to catastrophic events. This is likely due to the affinity of the species for mainstem rivers, thus limiting the ability of the species to survive catastrophes in tributaries (USFWS, 2023).

Population Growth Rate:
unknown

Number of Populations:
1 (USFWS, 2023)

Population Size:
unknown

Minimum Viable Population Size:
unknown

Adaptability:
Low

Population Narrative:
Historically, the species was split into two isolated populations in the Pascagoula River drainage and Pearl River drainage, but as the species has not been collected from the Pearl River drainage since 1973 it is considered extirpated from the drainage. A recent genetics study for the species showed pearl darter displays limited population genetic structure, where the populations throughout the Pascagoula River drainage are relatively genetically homogeneous but with sufficient allelic diversity throughout the drainage indicating only one biological population of pearl darter. As such, we delineated resilience units of pearl darter based on HUC8 watersheds with seven resilience units in the Pascagoula River drainage (Black Creek Unit, Chunky River Unit, Lower Chickasawhay River Unit, Lower Leaf River Unit, Pascagoula River Unit, Upper Chickasawhay River Unit, and Upper Leaf River Unit) and four resilience units in the Pearl River drainage (Bogue Chitto River Unit, Middle Pearl River Unit, Lower Pearl River Unit, and Strong River Unit) to most accurately describe trends in resiliency, forecast future resiliency, and capture differences in stressors among units (USFWS, 2023).

Threats and Stressors

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Non-point source pollution appears to be a localized threat to the Pearl darter within the drainage. Non-point source pollution from land surface runoff can originate from virtually any land use activity, and may include sediments, fertilizers, herbicides, pesticides, animal wastes, septic tank and gray water leakage, oils and greases. Construction activities that involve significant earthworks typically increase sediment loads into nearby streams. Siltation sources include timber clear cutting, clearing of riparian vegetation, and mining and agricultural practices that allow exposed earth to enter streams. Practices that affect sediment and water discharges into a stream system change the erosion or sedimentation pattern, which can lead to the destruction of riparian vegetation, bank collapse, and increased water turbidity and temperature. Excessive sediments are believed to affect the habitat of darters and associated fish species, by making the habitat unsuitable for feeding and reproduction. Sediment has been shown to abrade

and or suffocate periphyton, disrupt aquatic insect natural processes, and, ultimately, negatively affect fish growth, survival, and reproduction (Waters 1995, p. 55-62). Non-point source pollution is a more prevalent threat to the Pearl darter in areas outside those lands protected by The Nature Conservancy and other areas managed by the Forest Service and State of Mississippi where Best Management Practices (BMPs) are utilized.

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: In the Pascagoula drainage, water quality degradation and other biological impairment sources exist throughout the watershed (Mississippi Department of Environmental Quality 2008, pp. 13-15). Major problems with brine and dioxin have existed on several main tributaries to the Pascagoula including runoff into the Leaf River from Hattiesburg and the Leaf River Paper Mill at New Augusta. Brine water releases from oil fields on the Chickasawhay River (U.S. Fish and Wildlife Service 1990, p. 3) have also contributed to the degradation of water quality within the watershed. The dioxin advisory was removed in 1999 (Mississippi Department of Environmental Quality 1999, p. 59). However, continued concern exists about dioxin being contained in river sediment and the possibility of re-suspension of the chemical within the water column. Monitoring continues of the impacted water bodies. Laboratory results have established that fish are extremely sensitive to the effects caused by dioxins and it has been linked to declines in many fish populations (Hoffman et al. 2002, p. 1053). Brine discharges may produce acute toxicological effects when the salinity levels increase to a point greater than the physiological tolerance, thereby affecting the osmoregulatory mechanism of the fish. Oil well production brine also increases incidence of fish tumors, alters biotic community composition and eliminates benthic communities (Killebrew 1993, p. 215).

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: Municipal and industrial discharges into the Pascagoula watershed, particularly during low water, are concentrated and exacerbate water quality degradation including temperature, dissolved oxygen, and pH within all reaches of the Leaf River. Existing housing and urbanization along the banks of the Leaf River between I-59 and Estabutchie may contribute nutrient loading through sewage and septic water effluent. Bart and Piller (1997, p. 12) noted extensive algal growth during warmer months in the Leaf and Bouie Rivers, suggesting nutrient and organic enrichment which decreases dissolved oxygen and changes pH.

Stressor: Sand and gravel mining
Exposure:
Response:
Consequence:
Narrative: The American Sand and Gravel Company (ASGC) (1995, p. B4) considers the bed of the Bouie River a significant natural resource. Historically, ASGC has mined sand and gravel using a hydraulic suction dredge, operated within the banks of the Bouie River. Sand and gravel mining also has occurred within and adjacent to the Leaf River. Large sections of the river and its floodplain have been removed over the past 50 years resulting in the creation of very large, open

water areas that function as deep lake systems (ASGC 1995, pp.B4-B8). Pearl darters have not been collected in impounded waters and are intolerant of lentic (standing water) habitats. In addition to the creation of large, open water areas, in-stream sand and gravel mining also causes accelerated geomorphic processes, specifically headcutting, that adversely affects the flora and fauna of many coastal plain streams (Patrick et al. 1993, p. 90). Hartfield (1993, pp. 138-139) investigated the negative impacts of stream erosion due to headcutting on aquatic life in several Mississippi river drainages and believed that the drainages were also experiencing geomorphic instability caused by in-stream sand and gravel mining. Mining in active river channels typically results in incision upstream of the mine (by nickpoint migration) and sediment deposition downstream. The upstream migration of nickpoints, or headcutting, may cause undermining of structures, lowering of alluvial water tables, channel de-stabilization and widening, and loss of aquatic and riparian habitat. Geomorphic change, particularly headcutting, may cause the extirpation of riparian and lotic (flowing water) species (Patrick et al. 1993, p. 96). Lyttle (1993, p. 70) and Brown and Lyttle (1992, p. 2) found that in-stream gravel mining reduces overall fish species diversity in Ozark streams and favors a large number of a few small fish species.

Stressor: Impoundments
Exposure:
Response:
Consequence:
Narrative: The confluence of the Bouie and Leaf Rivers, within the Pascagoula drainage, possibly provides significant habitat for the Pearl darter. Fish collections from this area indicate that it may be a site critical for maintaining the current population of Pearl darters. Pearl darter locality records (1997) within the vicinity of the disturbed reaches of the gravel mine area of the Bouie River in Hattiesburg placed the species within the vicinity of a proposed dam (The Clarion-Ledger, October 28, 1998, p. 1B; Kemp Associates, PA, 2000, pp. 4-5). Maintaining a constant flow of water, free of impoundments will prevent alteration and fragmentation of Pearl darter habitat at the confluence of the Bouie and Leaf Rivers.

Stressor: Industrial development
Exposure:
Response:
Consequence:
Narrative: The U.S. Department of Energy (2006, pp. 2-35) tentatively proposes to expand the Strategic Petroleum Reserve in Perry County (Mississippi) at the Richton salt dome site by 2014. This potentially will reduce the Leaf River flow rate to below the minimum flow rate (water quantity) of 16.5 cubic meters per second (581 cubic feet per second). Approximately 204 million liters (54 million gallons) of water a day will be used to construct a cavern in the underground salt dome in order to stockpile strategic petroleum supplies. Reduction of flow rates in the Leaf River will correspondingly affect the flow rates of the Pascagoula River and may decrease the available habitat for the species (D. Drennen 2007, pers. observation.).

Stressor: Hurricanes
Exposure:
Response:
Consequence:
Narrative: Fish and aquatic communities and habitat, including that of the Pearl darter, may be changed by hurricane influences (Schaefer et al. 2006, pp. 62– 68). In 2005, Hurricane Katrina

destroyed much of the urban and industrial areas along the lower Pascagoula River basin and also impacted the ecology upriver to the confluence with the Leaf and Chickasawhay Rivers. Many toxic chemicals that leaked from grounded and displaced boats and ships, storage facilities, vehicles, septic systems, business sites, and other sources were reported in the rivers, along with saltwater intrusion from the Gulf of America. Initial assessment identified several fish kills and increased surge of organic material into the waters, which lowered dissolved oxygen levels (Schaefer et al. 2006, pp. 62–68) (USFWS, 2016)

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: The Intergovernmental Panel on Climate Change (IPCC) concluded that warming of the climate system is unequivocal (IPCC 2014, p. 3). Numerous long-term climate changes have been observed including changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns, and aspects of extreme weather including droughts, heavy precipitation, heat waves, and the intensity of tropical cyclones (IPCC 2014, p. 4). Species that are dependent on specialized habitat types, limited in distribution, or at the extreme periphery of their range may be most susceptible to the impacts of climate change (see 75 FR 48911, August 12, 2010); however, while continued change is certain, the magnitude and rate of change is unknown in many cases. Climate change has the potential to increase the vulnerability of the Pearl darter to random catastrophic events (Thomas et al. 2004, pp. 145–148; McLaughlin et al. 2002, pp. 6060–6074). An increase in both severity and variation in climate patterns is expected, with extreme floods, strong storms, and droughts becoming more common (IPCC 2014, pp. 58–83). Thomas et al. (2004, pp. 145–148) report that frequency, duration, and intensity of droughts are likely to increase in the Southeast as a result of global climate change. Kaushal et al. (2010, p. 465) reported that stream temperatures in the Southeast have increased roughly 0.2– 0.4 °C (0.3–0.7 °F) per decade over the past 30 years, and as air temperature is a strong predictor of water temperature, stream temperatures are expected to continue to rise. Predicted impacts of climate change on fishes, related to drought, include disruption to their physiology (e.g., temperature tolerance, dissolved oxygen needs, and metabolic rates), life history (e.g., timing of reproduction, growth rate), and distribution (e.g., range shifts, migration of new predators) (Comte et al. 2013, pp. 627–636; Strayer and Dudgeon 2010, pp. 350–351; Heino et al. 2009, pp. 41–51; Jackson and Mandrak 2002, pp. 89–98). However, estimates of the effects of climate change using available climate models typically lack the geographic precision needed to predict the magnitude of effects at a scale small enough to discretely apply to the range of a given species. Therefore, there is uncertainty about the specific effects of climate change (and their magnitude) on the Pearl darter; however, climate change is almost certain to affect aquatic habitats in the Pascagoula River basin through increased water temperatures and more frequent droughts (Alder and Hostetler 2013, pp. 1–12), and species with limited ranges, fragmented distributions, and small population size are thought to be especially vulnerable to the effects of climate change (Byers and Norris 2011, p. 18). Thus, we consider climate change to be a threat to the Pearl darter (USFWS, 2016).

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:

- The University of Southern Mississippi is continuing surveying the upper watershed of the Pascagoula River including the Chickasawhay and Leaf rivers (Jake Schaefer 2013-2014).
- The University of Southern Mississippi finished surveying the upper Pearl River (above the Ross Barnett Reservoir) for Pearl darters (2010-2011). No Pearl darters were found (Schaefer and Mickle 2011, pp. 1-14).
- The Mississippi Museum of Science (2011) completed the differentiation of population genetics and viability of the Pearl darter (Percina aurora) using microsatellite DNA markers through Section 6 funding (B. Kreiser 2011, pers. comm.).
- Conservation Fisheries Inc. (2006, pp. 1-10) has developed techniques for the propagation of Pearl darters. However, obtaining sufficient numbers of Pearl darters for husbandry efforts has been difficult and has met limited success.
- Protect habitat integrity and quality within the entire watershed.
- Promote voluntary stewardship to reduce non-point and point source pollution.
- Encourage and support community based watershed stewardship planning and action.
- Continue basic research concerning natural history and husbandry techniques of the species.
- Continue surveys for the species within the Pascagoula and the Pearl River watersheds.
- Continue networking with partners and other interested stakeholders through educational outreach and the use of best management practices.
- Maintain a minimum flow rate (water quantity) of 16.5 cubic meters per second (581 cubic feet per second)

References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2014

88 FR. No. 66. Pages 20410- 20430. Endangered and Threatened Wildlife and Plants

Designation of Critical Habitat for Pearl Darter.

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2014. USFWS. 2023. Species Status Assessment Report for the Pearl Darter (Percina aurora) Version 1.3. USFWS. Mississippi Basin Region Mississippi Ecological Services Field Office Jackson, Mississippi. 122 pp.

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2015

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2017

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2018

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2019

USFWS. 2016. Endangered and Threatened Wildlife and Plants

Threatened Species Status for Pearl Darter. Federal Register. Vol. 81, No. 183. Pages 64857-64868. Proposed Rule.

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2020

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2021

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2022

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 04/14/2023

SPECIES ACCOUNT: *Percina jenkinsi* (Conasauga logperch)

Species Taxonomic and Listing Information

Listing Status: Endangered; 8/5/1985; Southeast Region (R4) (USFWS, 2015)

Physical Description

A slender fish that attains a maximum length of about 4.6 inches. The sides of the body have numerous dark brown vertical bars set against a yellow-tan background on the upper half of the body and a light cream-white color on the lower half. The upper portion of the head is tan, and the rest of the head is a light cream color (USFWS, 1986).

Taxonomy

Not available

Historical Range

When the Conasauga logperch recovery plan was completed in 1986, the species was known to occur only in a 30-km reach of the Conasauga River, from just upstream of the Minnewauga Creek confluence in Polk County, Tennessee, downstream to the GA Hwy 2 bridge near Beaverdale, Murray County, Georgia (USFWS, 2011).

Current Range

Range includes the Conasauga River and Jacks River near its confluence with the Conasauga (Alabama River system), Tennessee and Georgia (Page and Burr 2011, USFWS 2011). (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 8/5/1985.

Legal Description

On August 5, 1985 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Percina jenkinsi (Conasauga logperch) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Tennessee and Georgia (50 FR 31597-31604).

The critical habitat designation for Percina jenkinsi includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Percina jenkinsi.

Critical Habitat Designation

The critical habitat designation for Percina jenkinsi includes one CHU (approximately 11 river miles) in Polk County, Tennessee and Murray County, Georgia (50 FR 31597-31604).

(1) Tennessee and Georgia: Conasauga River from the confluence of Halfway Branch with the Conasauga River in Polk County. Tennessee. downstream approximately 11 miles to the Georgia State Highway 2 bridge. Murray County, Georgia.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (50 FR 31597-31604):

(1) Constituent elements include high quality water, pool areas with flowing water and silt free riffles with gravel and rubble substrate, and fast riffle areas and deeper chutes with gravel and small rubble.

Life History

Feeding Narrative

Adult: Eats aquatic invertebrates obtained by flipping over stones with snout (Eager and Hatcher 1980). Adults and immatures are invertivores (NatureServe, 2015). Freeman (1990a) observed individuals actively foraging, often in close proximity to each other and usually in moderately deep areas with swift currents (USFWS, 2011).

Reproduction Narrative

Adult: Spawning occurs in spring (Biggins 1985). Individuals that apparently were spawning have been taken in late April and were taken from shallow gravel shoals with fast current (Etnier and Starnes 1993) (NatureServe, 2015). Captive mortality in Conasauga logperch suggests maximum lifespan is four years (Rakes and Shute 2005). No data are available on the age at which Conasauga logperch mature, but captive propagation studies on the closely related blotchside logperch (P. burtoni) suggest that these fish do not spawn until two years of age (Rakes and Shute 2005) (USFWS, 2011).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Environmental Specificity

Adult: Moderate (inferred from NatureServe, 2015)

Site Fidelity

Adult: High (inferred from NatureServe 2015; see dispersal/migration narrative)

Habitat Narrative

Adult: This species most often occurs in deep gravel runs or pools with small stones and sandy bottoms. Separation barriers are created by dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015).

Dispersal/Migration

Motility/Mobility

Adult: Not available (NatureServe, 2015)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal

Adult: Not available (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: This species is non-migratory. Data on dispersal and other movements generally are not available (NatureServe, 2015)

Population Information and Trends

Population Trends:

Declining (USFWS, 2011)

Species Trends:

Unknown (USFWS, 2011)

Resiliency:

A single population is known historically from a 35.5-mile reach of the mainstem Conasauga upstream 0.5 miles into the mouth of a tributary, the Jacks Rive. Population numbers in surveys are declining/absent in 26+ miles of the 36-mile known range. Resiliency low to very low due to stochastic or catastrophic events and/or current anthropogenic stressors. (USFWS, 2019)

Representation:

Evaluation of microsatellite markers indicated the species has maintained relatively high levels of heterozygosity and allelic richness Moderate Representation (USFWS, 2019)

Redundancy:

The Conasauga logperch is a narrow endemic species with a single, declining population and reduced habitat occupancy. There is no redundancy (USFWS, 2019)

Number of Populations:

1 (NatureServe, 2015)

Population Size:

< 200 adults (NatureServe, 2015)

Population Narrative:

Etnier and Starnes (1993) stated that the "population would appear secure for the foreseeable future as long as the excellent quality of the Conasauga River habitat is maintained." Total adult population size is apparently quite small. Catch per unit effort estimates conducted in the mid-2000s estimated the Conasauga logperch population at less than 200 adults (Anna George, Tennessee Aquarium Conservation Institute, pers. comm., Nov. 2008, cited by USFWS 2011).

The species is uncommon in its small range. "One of our rarest darters" (Etnier and Starnes 1993). Usually only 1-2 individuals per shoal are found during surveys; the largest number recorded per shoal was 13-14 (see USFWS 2011). This species is represented by a single occurrence (location, as defined by IUCN). Within the 55-km known range, the species has been observed at only 29 shoals since 1988. Individuals have been detected only once at 16 of these sites, and only two or three times at seven of the sites. At the other six sites (three upstream of the mouth of Perry Creek, one site between the mouths of Perry and Sumac Creeks, and two sites downstream of the mouth of Sumac Creek), the species has been detected on 4-10 occasions (Hagler et al. 2011). (NatureServe, 2015). The species status is uncertain; Conasauga logperch generally are found so infrequently that assessing a yearly trend is impossible. The best supported model Hagler et al. (2011) developed concluded that the probability of encountering a Conasauga logperch in the downstream third of the species' range declined over the past two decades. Genetic studies on nine Conasauga logperch specimens in the mid-2000's identified surprisingly high levels of genetic variation, with a bimodal distribution of characteristics between two sympatric clades of haplotypes (USFWS, 2011).

Threats and Stressors

Stressor: Habitat destruction and modification (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: The Conasauga logperch remains highly vulnerable to extinction and/or habitat destruction/degradation due to stochastic or human-induced events that degrade its habitat, including floods, drought, chemical spills, point-source contaminants, sewage spills, herbicides and pesticides, heavy metals, excess hormones and/or nutrients, and other factors. The River Road Reservoir, was constructed by Dalton Utilities off stream, in uplands adjacent to the middle portion of the Conasauga River in the late 1990s; it began withdrawing water from the Conasauga River to maintain reservoir water elevations, then releasing water during low flow periods for downstream withdrawal in 1999-2000. Increased silviculture, road and bridge construction, stream channel modification, and conversion of agricultural lands to urban use could significantly affect the logperch and its habitat due to increased stormwater runoff from impervious surfaces, greater water turbidity and sedimentation, higher contaminant loads, and other changes in water quality and timing/magnitude of stream flows (USFWS, 2011).

Stressor: Stochastic events (USFWS, 2011)
Exposure:
Response:
Consequence:
Narrative: The Conasauga logperch is highly vulnerable to extinction due to stochastic or human induced events, since it occurs only in small numbers in a short reach of a single river system. Stressors resulting from land use changes are likely to increase as the Cities of Atlanta and Chattanooga continue to expand northward and southward, respectively, into the Conasauga Basin (USFWS, 2011).

Stressor: Fine Sediment (USFWS, 2019)
Exposure:
Response:

Consequence:
Narrative: Fine Sediment (e.g., sand, silt, and clay): The detrimental effects of sediment on aquatic communities have been widely demonstrated and include (1) habitat degradation, (2) reduced productivity that affects the food chain, (3) lethal effects that kill individual fish, cause population reductions, or damage the capacity of the ecosystem to produce fish, (4) sub-lethal effects that injure the tissues or physiology of the organism but are not severe enough to cause death, and (5) behavioral effects that change activity patterns or alter the kinds of activity usually associated with an organism in an unperturbed environment (Newcombe and McDonald 1991, Wood and Armitage 1997). Specifically: • Fine sediments in the water column increase turbidity, limit light penetration, transport sorbed contaminants, and potentially reduce primary productivity that affects the food chain (Davies-Colley and Smith 2001). Lloyd et al. (1987) suggested that a turbidity of only 5 NTU from alluvial mining in Alaska could decrease the primary productivity of shallow clear-water streams by 3-13%, while an increase of 25 NTUs could cause a 13-50% productivity decrease in shallow streams. Van Nieuwenhuyse and LaPerriere (1986) found a 170 NTU turbidity caused a 50% reduction in primary production, while a 1200 NTU resulted in no primary productivity. • Deposited silt and sediment can entomb and smother the stream bottom, filling interstices between cobble and gravel particles. This can alter the periphyton and macroinvertebrate communities (Puglsey and Hynes 1983, Soroka and MacKenzie-Grieve 1983, Newcombe and Jensen 1996) and bury fish eggs, larval nurseries, and adult foraging and resting habitat. Walters et al. (2003) described how sediment delivery and deposition in the Etowah River basin resulted in homogenized fish assemblages by creating turbid streams and embedded channel beds. Berkman and Rabeni (1987), in a study of Missouri streams, noted that that, as siltation increased, abundance of two fish feeding guilds - benthic insectivores (like the Conasauga logperch) and herbivores - was reduced as the percent of fine substrate increased. Community dominance changed from riffle-specific species to ubiquitous and run-specific species. • Benthic food organisms may be smothered by silt, reducing food biomasss and making items harder for visually-feeding fish to locate (Ryan 1991). • Suspended sediment can reduce spawning success. Studies have shown that increased levels of suspended sediment reduced success of both salmonids and minnows, many of which depend on clear water for visual reproductive cues (Burkhead and Jelks 2001). • Silt may have direct lethal effects on fish by clogging gillrakers and gill filaments (Bruton 1985, Newcombe and Jensen 1996). Acceptable levels may depend on the nature and concentration of the silt, water oxygenation and temperature, species and size of the fish, and concentration of suspended sediment to which it has become acclimated (Ryan 1991). (USFWS, 2019)

Stressor: Excess Nutrients/Cultural Eutrophication (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Excess Nutrients/Cultural Eutrophication: Nutrients, especially nitrogen and phosphorus, are essential for plant and animal growth, but excessive application and subsequent runoff into receiving waters, particularly at times when sensitive early-lifestages of many fish and aquatic invertebrates are present, can cause both eutrophication of aquatic systems and adverse impacts to aquatic communities. The chief effect of eutrophication is the stimulation of algal growth and shifts in the algal community, which can reduce water clarity and degrade water quality. Extensive algal blooms can alter habitat by covering gravel substrates where fishes forage and deposit eggs, and they can smother Podostemum (Freeman et al. 2017). Algal blooms limit light penetration, reducing growth, causing die-offs of plants in littoral zones, and lowering the

success of predators that need light to pursue and catch prey (Lehtiniemi et al. 2005). High rates of photosynthesis associated with eutrophication can deplete dissolved inorganic carbon and raise pH to extreme levels during the day. When dense algal blooms eventually die, microbial decomposition severely depletes dissolved oxygen, creating hypoxic or anoxic ‘dead zones' lacking sufficient oxygen to support most organisms. This can lead to fish kills, as well as more subtle changes in ecological structure and function, such as lowered biotic diversity and reduced recruitment in fish populations. Hypoxia and anoxia are more likely to occur in summer, when the solubility of oxygen decreases and oxygen demand (respiration rate) generally increases as temperature increases (National Academy of Science 2000). Increases in nutrient loads can stimulate the proliferation of pathogens that adversely impact fish and mussel species (Coyner et al. 2003) and potentially alter the availability of carbon to the aquatic habitat. Smaller streams depend on annual leaf fall to support biological diversity and productivity (Wallace et al. 1997), and inputs of nitrogen and phosphorus to surface waters may accelerate decomposition of leaf packs by 50%, disrupting annual carbon usage patterns and food web functions (Rosemond et al. 2015). Nitrate has also been implicated as an endocrinedisrupting chemical due to its potential to be converted to nitric oxide, which can modify steroidogenesis in aquatic animals (Hamlin et al. 2008). Nitrogen cycles rapidly among ammonium (NH4), ammonia (NH3), nitrate (NO3), nitrite (NO2), atmospheric nitrogen (N2) and organic nitrogen (i.e., N bound in the biomass of organisms), plus intermediate forms. Ammonium and nitrate are the forms most rapidly taken up by plants. Denitrification converts nitrate to atmospheric nitrogen, providing a mechanism for removal from the system. Water quality studies conducted 1997-2012 in the Conasauga documented both (1) an increasing trend in NO2+NO3 concentrations in a downstream direction and (2) comparatively higher concentrations of total nitrogen (around threefold) in 2011-2012 samples vs 1997-2000 samples (Hagler and Freeman 2012). Local spikes with very high concentrations of NO2+NO3 were measured at multiple sites in the mainstem 1997-2007, including a November 1998 sample with a concentration of 44.46 mg/l NO3+NO2 at Hwy 286 -- this value far exceeds the EPA’s Maximum Contaminant Level Goals of 10mg/l NO3 and 1 mg/l for NO2 safe drinking water standard (Freeman et al. 2007). From 2012-2013, Lasier et al. (2016) found nutrient enrichment of Conasauga surface waters was widespread, with concentrations of NO3 and phosphorus exceeding levels associated with eutrophication. NO3 was measured in surface waters from each of 15 sites, and phosphorus was common at all but the two most upstream sites (both in Tennessee), with both elements often exceeding harmful concentrations. Freeman and Wenger (2001) reported a large bloom of benthic algae in October 2000 that spanned almost 30 miles of the Conasauga from near the Tennessee Hwy 74 crossing to downstream of Tibbs Bridge. The bloom was evident below the Mill Creek (TN) and Perry Creek (GA) confluences, the first tributaries that drain watersheds with larger amounts of agricultural lands. The blooms occurred in shallow water (0.75m or less) where Conasauga logperch might occur; mats of algae covered Podostemum, and fishes were present in lower abundances in the areas with algal mats (Freeman et al. 2007). The same phenomenon was observed the following year, in October of 2001 and in years since, to a lesser extent (Freeman et al. 2007). Currently, water clarity is significantly reduced in the lower half of the Conasauga logperch’s range, where the fish is now collected rarely, likely due to high concentrations of diatoms and other algae (Freeman and Freeman 2019) that may affect foraging and spawning success (Mary Freeman, USGS, pers. comm., November 2018). Likely sources of nutrients include: • Agricultural fertilizers: In the Conasauga, there is widespread use of poultry litter as fertilizer for pastureland or row crops (Cindy Askew, NRCS, pers. comm., June 2008). Poultry litter is a mixture of manure, feathers, spilled food, and bedding material. However, surface spreading of litter on fields allows runoff from heavy rains to carry nitrogen, phosphorus, and other chemicals from manure into nearby streams. Poultry litter has a N:P ratio of 2:1 (Pierson et al. 2001). Since most crops and pasture grasses require an N:P ratio of 8:1, applying sufficient poultry litter to supply the nitrogen needs of crops and pasture will result in excess phosphorus application (Sharpley 1999, Sharpley et al. 2004). Phosphorus will bind to soil and is mobilized with sediment particles after heavy rains, and relatively high phosphorus concentrations have been measured in surface runoff for months following poultry litter application (Pierson et al. 2001). Litter can contain arsenic, which is formed from a chemical routinely used as a feed additive to prevent disease and stimulate growth (Mangalgiri et al. 2015). Other substances often found in poultry litter include fecal coliforms and other pathogens, other heavy metals, pesticides and larvicides used to control flies and litter beetles, estrogens and other hormones, and excess carbon, which can deplete dissolved oxygen in surface waters (Moore 1997). • Suburban development, including lawn fertilizer, discharges or leaks from wastewater treatment plants, and poorly-maintained and/or sited septic tanks. • Atmospheric nitrogen that is fixed by plants, through lightening, or other processes. (USFWS, 2019)

Stressor: Increased Impervious Surface Associated with Urbanization (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Increased Impervious Surface Associated with Urbanization: An urban area is defined as the entire landscape developed for residential, commercial, industrial, and transportation purposes, including cities, towns, suburbs, and exurban sprawl that has a density of >1 residential unit/2 ha (Wenger et al. 2009). Limited urbanization is anticipated in two tributaries that drain into the Conasauga in the species' range -- Mill Creek, which drains the City of Cleveland, Tennessee, and Sumac Creek in Georgia. Cleveland grew 7.9% from 2010 to 2018 (https://www.census.gov/quickfacts/fact/table/ bradleycountytennessee/PST045218). Sumac Creek drains Cohutta Springs and the new Georgia Ports Authority inland port north of Crandell; the inland port is expected to handle 100,000 containers per year and likely will attract other industry to the area. Many studies have demonstrated that fish assemblages respond to a gradient of urbanization, with sensitive fishes disappearing as urbanization increases (Klein 1979, Wang et al. 2000, 2001, Walters et al. 2003, Roy et al. 2005, Walters et al. 2005). The conversion of a forested or agricultural landscape into parking lots, buildings, and lawns produces a cascade of impacts to stream systems, including changes to hydrology, geomorphology, water temperature, and stream chemistry (Paul and Meyer 2001). Urbanization alters the way rain is conveyed to stream channels (Figure 10). In a vegetated ecosystem, some precipitation evaporates, returning to the atmosphere; some infiltrates into the ground; and the remainder becomes surface runoff, traveling via natural channels and man-made drainage systems to larger streams. The volume of evaporation vs. infiltration vs. runoff is governed primarily by the land's slope, vegetative cover, and infiltration capacity of the underlying soil (sand > clay> bedrock). Impervious and reducedpervious surfaces associated with urbanization, such as parking lots, roads, building roofs, and even lawns and playgrounds, alter the natural cycling of water in regions where infiltration and subsurface flow play major roles in the water cycle. The general result is a decrease in the volume of water that evaporates or percolates into the ground and an increase in volume of surface runoff entering stream systems (Booth 1991). Low impact development is an approach to site development and stormwater management that aims to mitigate the impacts of surface runoff to water bodies by reducing impervious surface and treating runoff using a treatment train of best management practices (BMPs), such as rain gardens, green roofs, swales, and permeable paving. Effective impervious area (EIA) is the

portion of the total impervious surface that is hydraulically-connected to a storm sewer system via stormwater drainage pipes, ditches, or other conveyance methods, without any stormwater BMPs to reduce or infiltrate flows or improve water quality. Changes to channel morphology are among the most common and visible effects of urban development and increased EIA on natural stream systems, particularly in channel reaches that are alluvial (Booth and Henshaw 2001). Leopold (1968), in a study of eastern US streams, found that urban channels tended "to have unstable and unvegetated banks, scoured or muddy channel beds, and unusual debris accumulation." And Booth (1991) described suburban streams as having a characteristic look: "Their beds are uniform, with few pools or developed riffles… Channel banks are raw and near-vertical, with incisions of one to many feet. The erosion of adjacent steep banks is constantly adding new sediment. Woody debris is small and sparse…. Finally, the aquatic organisms that thickly populate equivalent drainages in undeveloped settings are nearly absent." While the effects of urbanization on stream biota are mediated by a variety of factors (including hydrology, previous land use, soil type, water quality, geomorphology, temperature, and stream flow), changes in urban streams have been so consistently observed, worldwide, that scientists have a term for the ecological degradation - urban stream syndrome. Common, but not universal, attributes of urban stream syndrome include (summarized by Paul and Meyer 2001, Konrad and Booth 2005, Meyer et al. 2005, Walsh et al. 2005, O'Driscoll et al. 2010, and Kominkova 2012): • Increased flashy flows, with more frequent, larger flow events and faster ascending and descending peaks, and with reduced groundwater discharge and lower baseflows (Figure 11; although in some systems, baseflow may be augmented by wastewater treatment plant discharge, lawn irrigation, septic drainage, and other sources). Urban development appears to reduce shallow subsurface flow that supports wet-season baseflow but has a less evident effect on deeper groundwater recharge that supports summertime discharges. Reduced summer baseflows can cause fish mortalities due to reduced flow velocity, crosssectional area within the channel, and water depth. The increased peak flows after rain events can wash fish eggs downstream and displace newly-emergent juveniles. Even movements of adults may be limited when water velocity exceeds a species' swimming speed. High velocities are especially damaging when there is a lack of roughness, such as large woody debris and boulders, which provide eddies where fish can rest (summarized in Finkenbine et al. 2000). • Altered channel morphology and stability (Figure 12). Stream width and depth alter in response to long-term changes in sediment supply and bankfull discharge. As each parcel of land is converted to urban use, sediment from construction sites with poor erosion control is transported into streams during rain events, leading to channel aggradation. After construction ceases, sediment supply is reduced, but bankfull flows are increased due to increases in EIA. This leads to increased channel erosion as channels incise and widen to accommodate increased bankfull discharge. During channel evolution, the bed is likely to be unstable at many locations, degrading habitat for spawning, feeding and refugia, including for the Conasauga logperch and other riffle-dwelling species that rely on sediment-free gravel (Wenger and Freeman 2007). The sediment from channel widening and deepening will move through the system, leading to sedimentation and turbidity in downstream habitat. Once a watershed has been urbanized, and the channel has adjusted to the new flow regime, it will no longer be subjected to high sediment loads (Wolman 1967), and bed coarsening is observed (Robinson 1976). However, it can take 15 – 30 years for a streambed to recover from the initially-high sediment loads (Robinson 1976, Klein 1979). • Increased stream water temperature and urban contaminants due to removal of riparian vegetation and runoff of heated stormwater draining from warmed asphalt, concrete, and other impervious surfaces. Thermal stress may be chronic or acute; acute stress results in immediate mortality, while chronic thermal stress may be one factor contributing to a shift in the fish community structure from intolerant to tolerant (Krause et al. 2004). Elevated nutrients and contaminants from point- and non-point sources are transported in surface runoff or discharged from wastewater treatment plants or other sources (Table 6). The quantity of these pollutants per unit area delivered to receiving waters tends to increase with the degree of development in urban areas. • Reduced fish and macroinvertebrate richness. Wenger et al. (2008) and Wenger (2008) evaluated the relationship of fish occurrence with effective impervious area (EIA) for five small fishes that occur in the Etowah River, another Upper Coosa tributary. Occurrence probability for the Etowah darter (Etheostoma etowahae), tricolor shiner, and speckled madtom (Noturus leptacanthus) was predicted to approach zero at levels of development equivalent to about 2%–4% EIA. Other species more closely related to the Conasauga logperch were slightly more tolerant – the occurrence probability approached zero at about 5% EIA in the upstream watershed for the bronze darter (Percina palmaris) and 10% EIA for the endangered amber darter (Percina antesella). • Other changes in an urbanizing area include (1) Fewer small streams in the network, as these streams are channelized, hardened or armored with concrete or riprap, culverted for roads and driveways, piped for storm drains, filled to allow land development, impounded for ponds, and other impacts; (2) Loss of mainstem and tributary channels for impoundments for flood control, drinking water, hydropower and other functions; (3) reduced stream flows due to water withdrawals; and (4) removal of riparian vegetation, which reduces stream cover and organic matter inputs, impacts stream temperatures, and leaves banks vulnerable to erosion.(USFWS, 2019)

Stressor: Glyphosate-Based Herbicides (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Glyphosate-Based Herbicides: In 1996, Monsanto introduced Roundup® Ready® soybean, a genetically-engineered crop resistant to the herbicide glyphosate. Roundup® Ready® corn was released in 1998, followed by canola, alfalfa, cotton, and sorghum. All are resistant to glyphosate due to a gene taken from a bacterium, Agrobacterium sp. strain CP4, which has been incorporated into the plant’s genome Padgette 1995). Glyphosate works by blocking an enzyme in the metabolic route a plant uses to biosynthesize foliates and aromatic acids (aka, the shikimate pathway). The bacterium gene codes for a glyphosate-insensitive form of this enzyme (Funke et al. 2006). Roundup® Ready® crops improve a farmer's ability to control weeds, since glyphosate can be sprayed in the fields at any time during the growing season, rather than early in the spring before seedlings emerge. Globally, glyphosate use has risen 15-fold since Roundup® Ready® crops were introduced; not only has the herbicide been sprayed on more land acreage, it has been applied more intensively, with more applications per unit area in a given crop year, and at higher one-time rates of application (Benbrook 2016). Most herbicide formulations are a mixture of an active ingredient (the pesticide) with a variety of “inert” chemicals, such as solvents and surfactants. The original Roundup®® formulation included the active ingredient glyphosate, plus the surfactant polyethoxylated tallow amine (POEA), which helps glyphosate better stick to leaves and penetrate plant tissues. Other glyphosate-based herbicides (Table 7) may include POEA or other surfactants (Defarge et al. 2018), and farmers often eschew Roundup®® and mix generic glyphosate with dish soap or diesel as the surfactant. Research has documented that glyphosate-based herbicides with POEA are more toxic to fish and other aquatic organisms than glyphosate alone (Folmar et al. 1979, Mitchell et al. 1987, Diamond and Durkin 1997), and POEA is more toxic than Roundup®® (Tsui and Chu 2003), particularly in alkaline water vs. acidic water (Diamond and Durkin 1997). In the Conasauga, Lasier et al. (2016) collected post-rainfall surface

water and sediment samples from the mainstem and major tributaries 2010-2013 and analyzed for glyphosate and one of its primary breakdown products, aminomethylphosphonic acid, or AMPA. Glyphosate was not detected in any surface water samples (N = 129). AMPA, however, was measured in 77% of the samples, with highest concentrations from the mainstem and tributaries draining the largest farm in the study area. Thirteen samples from the farm sites contained concentrations between 1000 and 5700 µg/L, and roughly 30% of the farm site samples exceeded 400 µg/L. Most of the elevated samples were collected during autumn and winter. The farm sites received discharges from tilled fields, pastures, and a dairy production facility. Glyphosate and/or AMPA (glyphosate and AMPA) were measured in almost all sediments collected from the mainstem and tributaries and ranged from below detection levels to 2428 µg/kg, with mean concentrations for collection sites (n = 9) varying from 200 to 1100 µg/kg. Current methods for analysis of POEA surfactants require significant time and effort. Lazier et al. (2016) estimated a surfactant concentration between 0.1 and 0.8 mg/L in surface water samples, based on AMPA concentrations (assuming that AMPA levels reflected glyphosate application, the surfactant was equally mobile as AMPA, and the landowner used a standard mix of glyphosate and surfactant). Depending on POEA's half-life (7-14 days in soil and 21- 42 days in water, Giesy et al. 2000 as cited in Struger et al. 2008, although it may be as low as 13-18 hours, Wang et al. 2005), this chemical's concentrations in the Conasauga mainstem could quickly fall below acutely toxic levels. However, repeated pulses of POEA (or other surfactants that may impair water quality or aquatic organism health) into surface waters at critical times may impact Conasauga logperch survival and recruitment, particularly at shoals adjacent to large farms with greater glyphosate-POEA herbicide application. Even below lethal levels, glyphosate-based herbicides appear to damage fish DNA. Roundup®® produced genotoxic damage in erythrocytes and gill cells of the streaked prochilod (Prochilodus lineatus) (Cavalcante et al. 2008) and caused significant dose-dependent increases in the frequencies of DNA damage in freshwater goldfish (Carassius auratus) (Çavas and Könen), tilapia (Tilapia rendalli) (Grisolia 2002), and European eels (Anguilla anguilla) (Guilherme et al. 2012). Roundup®® exposure caused oxidative stress in the liver and inhibited acetylcholinesterase in muscle and brain of streaked prochilod (Modesto and Martinez 2009); hormone profile and reproductive effects in silver catfish (Soso et al. 2007); and histopathological changes and gill tissue damage in Nile tilapia (Oreochromis niloticus) (Jiraungkoorskul et al. 2003). Langiano and Martinez (2008) noted an increase in plasma glucose and catalase liver activity in streaked prochilod exposed to the herbicide, indicating, respectively, a typical stress response and activation of antioxidant defenses after Roundup®® exposure. In addition, Roundup®® induced several liver histological alterations that might impair normal organ functioning. Glyphosate-based herbicides may affect fish behavior. In a laboratory study to evaluate acute toxicity of a glyphosate-based herbicide, juvenile African catfish (Clarias gariepinus) swam erratically, were hyperactive, and had reduced body pigmentation. Faster opercula movement, surfacing, and gulping of air were observed, and, with an increase in duration of the exposure, swimming and body movements were retarded. Later, fish lost balance, became exhausted, and lost consciousness, settling passively at the bottom of the tank with the operculum wide open. They ultimately died (Ani et al. 2017). Glyphosate's capacity to degrade rapidly is often used to argue against potential long-term toxicological effects associated with application. However, the herbicide is a phosphonic acid ($C_3H_8NO_5P$), and its degradation in the environment releases inorganic phosphorus. Hebert et al. 2019 summarized the transport of glyphosate in agricultural landscapes (Figure 14): Once sprayed (and ignoring atmospheric loss), glyphosate can either penetrate the soil surface directly or be absorbed by plants via their foliage and translocated via phloem down to the roots, where it is exuded into the soil. In the soil, a fraction of glyphosate can be transported by runoff or can leach into surface waters, either directly following application or after a period of soil storage; another fraction can also be assimilated by nearby non-target plant roots. Most glyphosate, however, will adsorb to soil particles, with soil retention capacity depending on soil mineral content, pH, and phosphate (PO43–) content, either natural or originating from other anthropogenic inputs, such as fertilizers. By adsorbing to soil, glyphosate may compete with PO43– for sorption sites, potentially influencing the mobility of glyphosate and/or PO43–; the extent of these processes may vary with soil composition and structure. Soil micro-organisms degrade glyphosate through two chemical pathways (Figure 14) -- one pathway produces AMPA, the second produces the compound sarcosine, which is oxidized to glycine and formaldehyde (Kishore and Jacob 1987, Hebert et al. 2019), and both degradation pathways release inorganic phosphorus. Glyphosate's application inevitably leads to greater anthropogenic phosphorus input in the agricultural landscapes where it is used and potentially to greater export from soils to water bodies (Hebert et al. 2019). (USFWS, 2019)

Stressor: Lack of Forested Riparian Zones (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Lack of Forested Riparian Zones: Riparian zones are lands adjacent to streams and shorelines, through which overland and subsurface flow paths connect runoff from uplands with waterways (Figure 15). Much of the Conasauga mainstem within Conasauga logperch habitat, as well as the ditches and tributaries that drain many agricultural fields, lacks a forested riparian buffer or has only fringe vegetation at top of bank. Deforestation of riparian areas can influence the numbers and kinds of organisms in adjacent and downstream reaches. Jones et al. (1999) sampled fishes and stream habitats in Tennessee River tributaries downstream from deforested, but vegetated, riparian patches; all sample reaches were downslope from watersheds with at least 95% forest cover. Darters, sculpins, and benthic minnows decreased in numbers with increasing length of nonforested riparian patch, and sunfishes and water-column minnows increased. Habitat diversity decreased, and riffles became filled with fine sediments as upstream patch length increased. Results suggested that riparian forest removal leads to shifts in the structure of fish assemblages due to (1) decreases in fish species that do not guard hidden eggs or that are dependent on swift, shallow water that flows over relatively sediment-free substrates, or (2) increases in fishes that guard their young in pebble or pit nests or that live in slower, deeper water. In addition to maintaining habitat for fish and other aquatic organisms, forested riparian buffers play a critical role in protecting stream habitat and water quality by (summarized in Pusey and Arthington 2003, Osborne and Covacic 1993): • Trapping/removing sediment, nutrients, and contaminants from runoff. This function may be greatly reduced or circumvented in the Conasauga, where agricultural ditches conveying runoff bypass the buffer. • Stabilizing streambanks by reinforcing and increasing soil cohesion and providing a protective surface matting. Trees and shrubs use water in the banks and increase drainage, which reduces the risk of bank failure due to saturated soils. Turfgrasses and crops slow runoff, but their root systems are too shallow to provide much streambank stabilization. • Storing and reducing the velocity of floodwaters, lessening the erosive force of a flood. • Shading streams to moderate water temperatures. Lower water temperatures support higher dissolved oxygen levels which are important to maintain fisheries. • Providing leaf litter and large woody debris. Large woody debris creates habitat diversity, provides nutrients for benthic invertebrates, leads to the formation of undercut banks and pools, and shelters fish from high flows and predators (Finkenbine et al. 2000). Leaf litter is an important source of food in smaller stream systems,

although in medium-sized rivers, like the Conasauga, aquatic vegetation, algae, and other autochthonous sources likely provide most of the channel's organic matter (Schlosser and Karr 1981). • Providing habitat for adult insects whose larval forms are aquatic and are a major food source for many freshwater fish. (USFWS, 2019)

Stressor: Decline in the abundance of Podostemum (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Decline in the abundance of Podostemum: Podostemum is a filamentous dicotyledon that occurs in mid-order montane and Piedmont rivers of eastern North America, where it grows submerged and attached to rocks and stable substrates in swift, aerated water (Figure 16). Widespread Podostemum population declines have been recorded across the species' range (Wood and Freeman 2017, Davis et al. 2018), including in the Conasauga River. Reasons for the decline are not known but may be related to sedimentation, epiphytic over-growth, hydrologic changes that result in desiccation, and possibly increased herbivory pressure (Wood and Freeman 2017). The presence of Podostemum can alter the physical structure of the channel by changing flow regimes (Grubaugh and Wallace 1995), which can affect sedimentation, organic deposition, and nutrient concentrations in the sediments – flow velocity within Podostemum beds can be decreased by more than 50% compared to flow above the plant beds in a Piedmont stream (Grubaugh and Wallace 1995). The plant stabilizes channel substrate to which it is attached, slowing the rate of downstream bed movement. Podostemum has been shown to increase invertebrate productivity of Piedmont streams (Grubaugh and Wallace 1995). Conversely, reductions in Podostemum biomass have been found to substantially decrease macroinvertebrate biomass, which may trigger trophic cascades that negatively impact fishes and other large bodied consumers (Davis et al. 2018). One hypothesis for the association between benthic fishes and Podostemum is preference for sites with increased food availability, but the fishes may also use the plant as a refuge from predators or from swift currents (Argentina 2006). (USFWS, 2019)

Stressor: Climate Change (USFWS, 2019)
Exposure:
Response:
Consequence:
Narrative: Climate Change: Earth's average surface temperature has risen 1.62F since the late 19th century, a change driven largely by increased carbon dioxide and other human-made emissions into the atmosphere. Most of the warming occurred in the past 35 years, with the five warmest years on record since 2010. The oceans have absorbed much of this increased heat, with the top 700 meters (about 2,300 feet) of ocean showing warming of more than 0.4 degrees Fahrenheit since 1969. (NOAA https://climate.nasa.gov/causes/). Climate change may increase extinction risk for many terrestrial and freshwater species during and beyond the 21st Century. The Fourth National Climate Assessment, released by the U.S. Global Change Research Program in November 2018, states "Observations collected around the world provide significant, clear, and compelling evidence that global average temperature is much higher, and is rising more rapidly, than anything modern civilization has experienced, with widespread and growing impacts. The warming trend observed over the past century can only be explained by the effects that human activities, especially emissions of greenhouse gases, have had on the climate." The Assessment stated annual average temperature over the contiguous United States increased

1.2°F (0.7°C) for the period 1986–2016 relative to 1901–1960 and projected, with high to very high confidence, that (Jay et al. 2018): • Annual average temperature over the contiguous United States would rise about 2.5°F (1.4°C) for the period 2021–2050 relative to the average from 1976–2005, with greater changes at higher latitudes as compared to lower latitudes. • Additional increases in temperatures across the contiguous United States of at least 2.3°F relative to 1986–2015 are expected by the middle of this century. • By late this century, increases of 5.4-11°F would occur if immediate and substantial mitigation to reduce greenhouse gas emissions was not implemented by mid-century, with greater reductions thereafter (Scenario RCP8.5; status quo). Increases of 2.3°–6.7°F were expected even under a scenario (RCP4.5) where late century global annual carbon emissions were significantly reduced (85%) relative to today (Figure 17). • High temperature extremes, heavy precipitation events, high tide flooding events along the U.S. coastline, ocean acidification and warming, and forest fires in the western United States and Alaska will continue to increase. • Land and sea ice cover, snowpack, and surface soil moisture will continue to decline. The effects of climate change on aquatic species in the Conasauga River have not been studied. In the Southeast through the 21st century, variability in weather is predicted to increase, resulting in more frequent and extreme dry and wet years over the next century (Mulholland et al. 1997, Ingram et al. 2013). Climate models project that average annual temperatures will increase, cold days will become less frequent, the freeze-free season will lengthen by up to a month, heat waves will become longer, temperatures exceeding 95F will increase, sea levels will rise an average of 3 feet, the number of category 3 to category 5 hurricanes will increase, and air quality will decline (Ingram et al. 2013). Aquatic systems will be impacted by increasing water temperatures, decreasing dissolved oxygen levels, altered streamflow patterns, increased demand for water storage and agricultural irrigation, and increasing toxicity of pollutants (Ficke 2007, Rahel and Olden 2007). Reduced spring/summer rainfall, coupled with increased evapotransporation and water demand (because of population growth), could lead to local extirpations if streams dry out more frequently (Ingram et al. 2013). Fishes not constrained by movement barriers could move upstream to cooler waters; however, even historically, the Conasauga logperch was not known to occur in the river in the Alaculsy Valley, where it may be too small, have unsuitable geomorphology, or have unsuitable water chemistry to support the species. (USFWS, 2019)

Recovery

Reclassification Criteria:
Reclassification objectives for this species cannot be developed at this time (USFWS, 1986).

Delisting Criteria:
1) A stable, self-sustaining population in the Consauga River, as evidenced by population trends over multiple spawning cycles. 2) Eighty percent of shoals within the historic range are consistently occupied by the species. 3) Key water quality standards are met such that the species will remain viable, based on Population Viability Analysis (PVA) or other scientifically-defensible evaluation methods, for the foreseeable future. 4) Consauga logperch are protected form habitat threats and/or managed such that the species will remain viable, based on PVA or other scientifically-defensible evaluation methods, for the foreseeable future. (USFWS, 2019)

Recovery Actions:
- Preserve Conasauga River populations and presently used habitat of the Conasauga logperch (USFWS, 1986).

- Search for additional populations and/or habitats suitable for reintroduction efforts (USFWS, 1986).
- Determine the feasibility of reestablishing the Conasauga logperch back into suitable stream reaches that are determined to have been historic habitats (USFWS, 1986).
- Develop and implement a program to monitor population levels and habitat conditions of presently established populations as well as any newly discovered, introduced, or expanding populations (USFWS, 1986).
- Annually assess overall success of the recovery program and recommend action (changes in recovery objectives, delist, continue to protect, implement new measures, other studies, etc.) (USFWS, 1986).
- Continue ongoing work to implement agricultural best management practices, riparian vegetation restoration, and streambank stabilization work on the Conasauga mainstem and Holly Creek, and expand actions to include priority tributaries (USFWS, 2011).
- Continue monitoring Conasauga logperch populations and fish communities at benchmarked sites to evaluate population trends, changes in community structure, and habitat alterations (USFWS, 2011).
- Continue Conasauga logperch genetic and propagation studies and provide funds for long-term support of at least one ark population in captivity (USFWS, 2011).
- Continue studies to determine contaminant loads and sources in the basin (USFWS, 2011).
- Conduct Conasauga logperch life history research, including characterizing juvenile habitat and evaluating patterns of population structure and connectivity (USFWS, 2011).
- Work with local governments, business, industry, and others to develop a Conasauga Basin Regional Aquatic Habitat Conservation Plan to minimize adverse effects of future urban development on Conasauga logperch (e.g., stormwater runoff) (USFWS, 2011).
- Identify areas of suitable, unoccupied Conasauga logperch habitat within the species historic range and determine if translocation of captive-bred specimens is appropriate. If so, develop release techniques and work with landowners to reestablish populations in these reaches (USFWS, 2011).
- Work with local officials to develop county- and city-wide ordinances to minimize the impact of stormwater runoff, sediment and erosion, road and utility stream crossings, and other urban stressors on Conasauga logperch and other rare basin species (USFWS, 2011).
- Develop and implement programs and materials to communicate to government officials and the public on the need and benefits of ecosystem management and to involve them in watershed stewardship for these and other aquatic species (USFWS, 2011).
- Work with State and local governments, as well as private landowners in these basins, to identify and implement best management and conservation practices to improve water quality and water quantity issues (USFWS, 2011).
- Continue to hold periodic Conasauga and/or Coosa Summits to bring together researchers, land managers, environmental groups, local government officials, and others to discuss recent Conasauga/Coosa research results, new threats, and needed management actions. Continue to meet in smaller committees, as needed, to discuss management actions to address stressors (USFWS, 2011).

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SPECIES ACCOUNT: *Percina pantherina* (Leopard darter)

Species Taxonomic and Listing Information

Listing Status: Threatened; 02/27/1978; Southwest Region (R2) (USFWS, 2016)

Physical Description

The leopard darter is a small (up to 8.7 cm total length), percid fish, tan to olive in color, with a distinctive pattern of 11-14 round black spots along each side. This species is endemic to the Little River basin of southeast Oklahoma and southwest Arkansas and has always been reported as rare. Several ichthyologists recommended providing special protection to the leopard darter (Miller 1972, Cloutman and Olmstead 1974, Robison et al. 1974, Hubbs and Pigg 1976). On January 27, 1978, the leopard darter was listed as a threatened species under the Act, and several areas within the Little River basin were designated as critical habitat (43 Federal Register 19:3711-3716).

Taxonomy

The leopard darter is distinguished from the blackside darter by having a row of 11-14 round black spots along the lateral sides, whereas the lateral blotches of blackside darters are fewer than 10 and tend to be longer than they are deep (USFWS, 1993).

Current Range

Leopard darters currently occupy portions of the Little River upstream of Pine Creek Reservoir, Glover River upstream of the vicinity of the community of Glover, Oklahoma, Mountain Fork River upstream of Broken Bow Reservoir, Robinson Fork River upstream of its confluence with Rolling Fork River, and Cossatot River upstream of Gillham Reservoir. Populations have also been found in some of the larger tributaries of these rivers. Leopard darters have never been reported from the Rolling Fork or Saline river drainages in Arkansas.

Critical Habitat Designated

Yes; 1/27/1978.

Legal Description

On January 27, 1978 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Percina pantherina (Leopard darter) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Oklahoma (43 FR 3711-3716).

The critical habitat designation for Percina pantherina includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Percina pantherina.

Critical Habitat Designation

The critical habitat designation for Percina pantherina includes one CHU in McCurtain and Pushmataha Counties, Oklahoma (43 FR 3711-3716).

Oklahoma, McCurtain and Pushmataha Counties - Little River, main channel in Pushmataha County from mouth of Cloudy Creek (T. 3 S.; R. 20 E.; Section 3) upstream to the Pushmataha-Le Flore County line. Black Fork Creek in Pushmataha County from its junction with Little River (T. 1 S.; R. 20 E.; Section 22) upstream to Oklahoma Highway 144 crossing (T. 1 S.; R. 19 E.; Section 12). Glover Creek, main channel in Pushmataha County from Oklahoma Highway 7 crossing (T. 5 S.; R. 23 E,; Section 28) upstream to the junction of the East Fork and West Fork of Glover Creek. East Fork and West Fork of Glover Creek. East Fork of Glover Creek, main channel in Pushmataha County from its junction with the West Fork Glover Creek (T. 3 S.: R. 23 E.; Section 7) upstream to 4 air miles north-northeast of the community of Bethel (T. 2 S.; R. 24 E.; Section 5). West Fork Glover Creek, main channel in Pushmataha County from its junction with the East Fork Glover Creek upstream to the community of Battiest (T. 2 S.; R. 23 E.; Section 7). Mountain Fork Creek, main channel in McCurtain County, from mouth of Boktukola Creek (T. 2 S.; R. 25 E.; Section 9), 6 air miles south-southwest of Smithville, upstream to the Oklahoma-Arkansas State line. Arkansas. Polk County. Mountain Fork Creek, main channel from the Arkansas-Oklahoma State line upstream to the community of Mountain Fork (T. 1 S.; R. 32 W.; Section 29).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified (43 FR 3711-3716):

Life History

Feeding Narrative

Adult: Darters are typically first- and second-order carnivores that feed mainly on micro-crustaceans as juveniles and on immature aquatic insects as adults (Page 1983). Mayfly nymphs (Ephemeroptera: Baetidae and Heptageniidae), blackfly larvae (Diptera: Simuliidae), and midge larvae (Diptera: Chironomidae) were the only food items found in stomachs of 19 leopard darters examined by James et al. (1991). Blackfly larvae Simulium sp., and mayfly Pseudocloen sp. nymphs were the major food items in seven leopard darter stomachs examined by Robison (1978). A more recent study by Williams et al. (2006) which examined leopard darter food habits from 1994 to 1997 found Baetidae, Chironomidae, and Heptageniidae to be the most common families of aquatic insects found in leopard darter stomachs. No information on feeding behavior, such as time of feeding, feeding intensity, or seasonal shifts in feeding patterns exists for the leopard darter. Page (1983) states that darters, as a group, have keen vision and are likely to be diurnal, visual feeders. Examination of published literature indicates that considerable dietary overlap may exist between leopard darters and other sympatric Percina species. For example, dietary preferences of logperch Percina caprodes and channel darters P. copelandi in the Glover River consisted largely of dipterans (chironomids) and ephemeropterans (Jones and Maughan 1987).

Reproduction Narrative

Adult: Leopard darters migrate from pools to riffle tailwaters in search of suitable spawning habitat during February and early March when water temperatures reach 10-12°C (James 1988, James and Maughan 1989). Spawning occurs from mid-March through mid-April on riffles at water temperatures of 12-17oC (James 1988). The non-adhesive, demersal eggs are buried in patches of fine gravel (3-10 mm in diameter) at water depths of 30-90 cm and current velocities of 10-35 cm/second (James 1988, James and Maughan 1989). Eggs hatch in about 7 days at 20oC, and larvae presumably drift downstream into pools (James 1989). The number of mature and immature ova examined in seven specimens varied from 260 to 2,302 (Robison 1978). James et al. (1991) examined 5 preserved specimens and found that distinguishable ova varied from 294-757, with a mean of 465 ova per female. Observations of spawning females in captivity by James et al. (1991) indicated that clutch size averaged 58.5 and fertilized, water hardened eggs had a mean diameter of 1.4 millimeters (mm). All spawning individuals appeared to be age-I and high mortality of these individuals apparently occurs following spawning season (James et al. 1991, James 1989). Continued survival of leopard darter populations is dependent upon age-I individuals because of the small number of adults surviving to age-II or older.   Age and Growth Jones et al. (1983) measured the total length of 137 leopard darters collected in the Glover River. Total lengths varied from 45 to 92 mm, with a mean of 70 mm. Leon et al. (1987) provided information on total and standard lengths of 16 leopard darters collected from the Cossatot and Robinson Fork Rivers. Total lengths varied from 24 to 69 mm and standard lengths varied from 21 to 59 mm. Mean standard lengths reported by James et al. (1991) from the Glover River varied from 18 to 81 mm. Growth of young-of-the-year appears to be extremely rapid with most individuals attaining an adult size within 5 to 6 months.   Scale analysis of 14 preserved specimens by Jones et al. (1983) determined that leopard darters 53 to 74 mm total length were one year of age and those 74 to 80 mm total length were two years of age. Based on this information, Jones et al. (1983) assigned ages to the following size classes: <50 mm total length - age 0, 51 to 71 mm - age I, 72 to 87 - age II, and >87 mm total length - age III. Using these measurements, the distributions of captured individuals within the various age groupings were: 0+ - 1.5 percent, I+ - 63.5 percent, II+ - 32.0 percent, and III+ - 3.0 percent (Jones et al. 1983). Robison (1978) collected a mature female, 77 mm standard length, which was reported to be 3+ years of age. Jones et al. (1983) also reported the capture of four individuals exceeding 88 mm total length equivalent to the 3+ age category.

Habitat Narrative

Adult: The leopard darter typically inhabits pools having predominantly rubble and boulder substrates with current velocities less than 48 cm/second (Jones 1984, Lechner et al. 1987). Preferred water depths are generally 20-102 cm (Jones et al. 1984; James 1989), although joint Service/FS surveys over the past 10 years have observed leopard darters from depths over 4.0 m. Juvenile and adult leopard darters inhabit pools almost exclusively from June through early February.   However, during the spring and winter, riffles and runs may occasionally be used. Riffle habitats increase in importance during the reproductive season (February through April).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Leopard darters migrate into riffles during spring to spawn; the magnitude of these migrations is unknown, but leopard darters may migrate into headwater reaches and tribtaries during the spawning season (James and Maughan 1989).; Nonmigrant: N; Local migrant: Y; Distant migrant: N;   (NatureServe, 2015)

Population Information and Trends

Number of Populations:

4 (USFWS, 2023)

Population Narrative:

Leopard darters are an annual species exhibiting very high mortality rates. James et al. (1991) observed that leopard darter mortalities in the Glover River between July and September averaged about 60 percent during 1987 and 1988. These observations led to the conclusion that maximum longevity for leopard darters is about 18 months. James (pers. comm. with K. Collins 1992) tracked the growth of two complete cohorts in the Glover River and found no individuals which could be considered as age III+. Many of the age I+ individuals were between 70 and 80 mm standard length. Estimates of density (number of individuals/unit area of habitat), although highly variable and often biased, can be a useful indicator of the number of organisms occurring within a particular portion of their habitat. However, densities of leopard darters within the basin are not well documented. Jones et al. (1983) first reported densities for the Glover River on a per length of stream basis. Using electro-fishing techniques, they reported leopard darter densities of 0 to 27 individuals per 100 m of stream. Since that time, several others have reported leopard darter densities on a unit area basis for a few additional localities. Observed densities (Appendix A) have varied from 0.0 to 0.65 darters/m2, depending upon the method used to determine leopard darter abundance. Maximum densities determined from underwater observations tend to be roughly 38 times higher than those calculated using electro-fishing data and likely provide a more accurate representation of actual abundance. Densities reported for Big Eagle Creek were considerably higher than densities observed in other locations. Leopard darters are generally more abundant in the Mountain Fork, Glover and Little River drainages than in the Cossatot and Robinson Fork drainages (James 1989). The largest population(s) of leopard darters likely occurs in the main channel of the Glover River (Taylor and Wade 1972, Eley et al. 1975, James 1989, Zale et al. 1994). Prior to 1985, 125 separate collecting attempts from approximately 56 different localities resulted in collection or capture of only 333 leopard darters: 31 from 10 locations within the upper Little River drainage, 197 from 25 locations in the Glover River drainage, 48 from 13 locations in the Mountain Fork River drainage, and 57 from 8 locations in the Cossatot River (Eley et al. 1975, Jones et al. 1984). Since that time, leopard darters have been reported captured from several additional localities (Zale et al. 1994, Collins 1993, 1995, 1998). Number of individuals observed or captured from any one site within the drainage basin varied from 1 to 128. Jones et al. (1983) estimated the number of leopard darters inhabiting the Glover River to be more than 2,800, including 786 in the river main stem. Later, James (1996) estimated that the leopard darter population in the Glover River ranged from 3,000 to 10,000 individuals. Subsequently, Williams, et al. (1999) attempted to estimate the abundance of leopard darters within the Little River basin using densities estimated from mark-recapture studies and the estimated amount of suitable habitat within the occupied reaches of each river system. The number of leopard darters was estimated to vary between 156,157 and 1,636,669 individuals. The average population size was estimated to be 777,976. The largest population was estimated to occur in the Mountain Fork River, followed by the Little River and then the Glover River. Leopard darter abundance in the Mountain Fork was estimated to be more than double the Little or Glover River populations and almost 100 times as large as the Robinson Fork River population. The Cossatot River was estimated to have the smallest number of leopard darters. Williams et al. (1999) conducted a population viability analysis for the leopard darter. The species appears to be reasonably secure considering its relatively large population sizes and high fecundity (Echelle et al. 1998). The probability and severity of drought and migration had the greatest effect on persistence of the species. The leopard darter has been described as being very sensitive to water quality and habitat degradation (Jester et al. 1992). Modeled extinction probabilities were not significantly different for small populations, such as those in the Robinson Fork, in comparison to larger populations like that of the Glover River or for the metapopulation as a whole. Allele frequency analysis revealed three primary clades: (1) populations in the Little and Glover Rivers, (2) populations from the Mountain Fork drainage, and (3) populations in the Robinson Fork and Cossatot Rivers (Echelle et al. 1999). Populations in the Little and Glover Rivers were more closely related to the Robinson Fork and Cossatot River populations than they were to the Mountain Fork River population. Polymorphism and heterozygosity was lowest in the Robinson Fork River and highest in the Mountain Fork River. However, these values were low when compared to related species of Percina and for most fishes in general. Most of the polymorphism was due to rare alleles, although the species as a whole harbors considerable allele diversity. The population in Buffalo Creek, and a similarly isolated population in Terrapin Creek, was not evaluated. In 1978, the leopard darter was federally listed under the Act as threatened. Critical habitat was also designated at the time, including portions of Black Fork Creek and the Glover, Little, and Mountain Fork Rivers. At the time of listing, four populations were known (Cossatot, Glover, Little, and Mountain Fork Rivers), all of which continue to persist, although the Cossatot River population continues to be in decline. The species has disappeared in the Cossatot downstream of Gillham Reservoir, as predicted in the 1978 listing. Monitoring results from 1998 to 2023 indicate populations in the Little, Glover and Mountain Fork are stable. The species may now be extirpated from the smaller Robison Fork Creek, however continued ongoing surveys within that drainage are needed (USFWS, 2023).

Threats and Stressors

Stressor: Habitat loss and degradation
Exposure:
Response:
Consequence:
Narrative: Habitat loss and degradation is the principal factor affecting survival of the leopard darter. Six major reservoirs, impounding all but one major stream (Glover River) in the Little River basin, have significantly reduced the distribution and abundance of the leopard darter. Historically, leopard darters inhabited reaches in the lower Mountain Fork, lower Cossatot and lower reaches of the upper Little River (Eley et al. 1975). These populations were extirpated following construction of Broken Bow, Gillham, and Pine Creek Reservoirs, respectively. Silviculture has been a major economic activity in the Little River basin since the early 1960's. The ensuing intensive commercial harvest (clear-cutting) of forest products has significantly altered the terrestrial environment of the basin. Terrestrial perturbations, primarily logging and associated road building, were thought to have caused a decline in the endemic fish fauna of southeastern Oklahoma (Rutherford et al. 1987) and may particularly affect small, short lived species (Rutherford et al. 1992). The leopard darter, with its short life span and restricted distribution is potentially vulnerable to the effects of land use alteration. The leopard darter recovery plan identified silviculture as a major threat to the survival of the species (Jones 1984). The effect of road construction, while not exclusively associated with timber extraction, is a related activity that can significantly influence fish populations. The upper Little River basin typically has a high density (for example, 2.0 km/km2 in the FS’s Broken Bow Unit) of unimproved roads providing access to thousands of hectares of pine plantations. Once revegetated, rates of erosion and sediment yield from pine plantations likely decline. However, erosion from logging roads declines only if traffic levels decrease following cessation of logging activity. Average sediment yield from roads in the Ouachita Mountains varies from about 0.085 to 0.018 metric tons/hectare/year (Miller et al. 1985, Scoles et al. 1995). Miller et al. (1985) expressed concern that the number of stream crossings may have a greater influence on sediment delivery to

streams than the actual area of roads. In addition, road crossings also may obstruct movements of many stream fishes (Warren and Pardew 1998). Poor crossing design, primarily improper size, number, or placement of culverts, can lead to excessive current velocities within culverts, scour pools with cascades downstream of the culvert, and elevated hydraulic head at culvert inlets. These barriers, combined with a lack of water velocity refugia, significantly influence movements by stream fishes. Recent investigations have shown that most existing crossings in the Little River drainage are a barrier to movement of leopard darters (Toepfer et al. 1999, J. Schaefer, pers. com. with K. Collins, 2000). Although low-water stream crossings are not likely to be long term barriers to leopard darter movements, they can temporarily restrict access to spawning areas and hinder re-colonization following periods of extended drought. Both of these factors likely affect the persistence of some leopard darter populations. Although no studies have specifically determined water quality requirements of leopard darters, water quality deterioration within the basin (due to agricultural and industrial activities) was also identified as a major threat to the survival of the leopard darter (Jones 1984). In 1976, a chemical spill eliminated leopard darters from about 19 km of the upper Mountain Fork River in Arkansas (Robison 1978). Agricultural activity within the basin, primarily the production of poultry and swine, also has been increasing over the past several years. Waste disposal from these operations typically involves land application and may include incorporation of wastes into the soil. Generally, proper disposal of wastes from these facilities poses little threat to leopard darters. However, disposal of these wastes is largely unregulated. Recent studies have documented the potential for serious water quality degradation if runoff from fields treated with swine and poultry manure is allowed to enter eastern Oklahoma streams (Sharpley et al. no date). Since 1992, Service biologists conducting leopard darter surveys have noted increased abundance of filamentous algae at multiple sites. This algal growth is likely the result of increased nutrient input within these reaches. However, the exact source of these nutrients is unknown and additional research is needed. Studies (Forshage and Carter 1973, Lyttle 1993) have documented reductions or eliminations of darter species in fish communities impacted by gravel dredging/removal operations. However, water quality degradation associated with commercial gravel dredging/removal operations does not appear to have a major impact on leopard darters at current activity levels. In 1994, the U.S. Army Corps of Engineers (Corps) granted a permit under Section 404 of the Clean Water Act authorizing the commercial removal of gravel from the Glover River. The Service’s Biological Opinion on this project estimated that one leopard darter and an area of habitat encompassing 60 m2 would be degraded annually as a result of the action.

Stressor: Livestock grazing
Exposure:
Response:
Consequence:
Narrative: Livestock grazing is an additional activity that occurs within the range of the leopard darter. Grazing has occurred in this area for at least the last 100 years, although the intensity of the activity likely increased beginning in the 1960's. In most areas grazing does not appear to have significantly impacted the riparian zone, although some grazing related habitat degradation has temporarily occurred in localized areas. However, in certain other reaches livestock access has degraded the riparian zone. In areas within the Ouachita National Forest, the FS is attempting to address the impacts of grazing on the riparian zone. Future grazing activities on the National Forest will be addressed through the section 7 consultation process.

Stressor: Climate Change (USFWS, 2023)

Exposure:
Response:
Consequence:
Narrative: Ongoing climate change is another factor potentially affecting aquatic organisms, including fish. Because the leopard darter generally spawns only once in its lifetime, fluctuations in population numbers from year to year can vary significantly (Appendix A, Figures 2-16). Given this sensitivity, climatological conditions such as precipitation and temperature could have significant effects on population numbers of leopard darter. If drought-like conditions occur over multiple years to the extent that suitable spawning temperatures become limited, leopard darter populations could be at risk for decline (USFWS, 2023).

Recovery

Recovery Actions:

- The Oklahoma Ecological Services Field Office of the Service should be contacted at least one week prior to start of construction to alert staff for purposes of monitoring bridge construction/removal and assisting contractors, if necessary;
- Crossing construction and removal of the existing bridge shall be conducted from July 1 to January 1 23 to avoid effects to leopard darter spawning and recruitment and allow time for any downstream sedimentation to be cleaned before the next years spawning season;
- The area of disturbance, due to crossing construction and removal, will be minimized to the greatest extent practicable;
- For any stream area proposed for dewatering, fish shall be removed and relocated downstream, to the greatest extent practicable.
- Disturbance within the wetted perimeter related to placement of center footing(s), construction of temporary jetties, sloping the channel upstream of the existing bridge, removal of the existing bridge and construction of the west embankment shall be limited to an area no greater than 1,590 2,668 m2 (Figure 1). The contractor or FS personnel shall monitor and record the amount of instream area disturbed throughout the project duration to ensure that the 1,590 2,668 m2 threshold is not exceeded;
- Channel resloping may occur in stages, but the contractor shall avoid, to the greatest extent practicable, manipulating areas that have already been resloped. Incidental take of leopard darters in this Opinion is based on a one-time impact to instream areas (Figure 1). If an area previously disturbed is left to recover, additional leopard darters may reoccupy the area and incidental take authorized in this Opinion could be exceeded;
- Either during project construction, or immediately following project completion, disturbed riparian areas shall be revegetated with native plants. Trees larger than 7.6 cm diameter at breast height (DBH) shall be replaced with trees of the same type at a1:3 ratio (for every tree removed, replace with three similar trees). Replacement trees shall be a minimum of 2.5 cm in diameter. Revegetation shall be managed to insure a survival rate of at least 80% of individual trees over a 5 year period following completion of the proposed action. If necessary, to achieve this survival made;
- Appropriate Best Management Practices, as established by the Oklahoma Department of Environmental Quality and FS, to reduce potential erosion and sedimentation, shall be incorporated into the project specifications and included as part of the project plans; and
- Hazardous materials, chemicals, fuels, lubricating oils, and other such substances shall be stored at least 31 m outside of the wetter perimeter. Refueling of construction equipment

also shall be conducted at least 31 m outside of the wetter perimeter.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS We will work with our partners to implement the following recommended actions during the next five-year review period: • Continue to support propagation efforts so that the PTAR plan to reintroduce or augment populations can be implemented. o Augment the Cossatot River population based in guidance in the Controlled PTAR for the Leopard Darter. This could be from hatchery propagated fish or through direct translocation of juveniles or adults from one tributary to the Cossatot River. • Research and identify leopard darter sub-populations within each major tributary to allow partners to better implement the Controlled PTAR plan. See the PTAR plan for additional discussion on what information is needed. • Continue to assess the possibly of capturing larval leopard darters to be used for augmentation or reintroductions. If successful, this approach could yield significant numbers to augment or reintroduce, including potentially high genetic diversity, while having minimal impact to the source population (as compared to removing adults for propagation work or direct translocation). • Continue to identify priority fish passage projects and seek out partnerships and funding to improve crossings. • Conduct additional research on the effects of run-off and increased sedimentation in the Little River Watershed. • Conduct a thorough analysis of the team's long term monitoring data set to identify drivers of occupancy and abundance of darters in the Little River watershed. • Conduct research on leopard darter movement to better to aid in decision making when determining fish passage projects. • Conduct a more thorough assessment of existing regulatory mechanisms in the Little River basin and if they are providing adequate protections for the leopard darter (USFWS, 2023).

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SPECIES ACCOUNT: *Percina rex* (Roanoke logperch)

Species Taxonomic and Listing Information

Listing Status: Endangered; 08/18/1989; Northeast Region (Region 5) (USFWS, 2015). Proposed for Delisting

Physical Description

Percina rex attains a length of 14 centimeters (5.5 inches), and is characterized by an elongate, cylindrical to slab-sided body, a conical snout, and complete lateral line. The back is dark green, sides are greenish to yellowish, and belly is white to yellowish. The upper sides and back have dark scrawlings and numerous small saddles. Bar markings on the side are prominent, usually separated from the dorsal markings, and typically ovoid in shape. The subocular bar and caudal spot are also well developed. The first dorsal fin has a narrow black margin, a broad yellowish to red-orange band, and a broad black base. Second dorsal, caudal, and pectoral fins have black spots (tesselated) with a yellowish wash. Pelvic and anal fins are typically pale. (USFWS, 1992)

Taxonomy

The Roanoke logperch was first collected in the Roanoke River near Roanoke, Virginia, in 1888 and described by Jordan (1889) as Etheostoma rex. It is now placed in the genus Percina (subgenus Percina), which contains all logperches, and is most closely related to the blotchside logperch, P. burtoni, and the Ohio logperch, P. caprodes (Simonson and Neves 1986). (USFWS, 1992)

Historical Range

See current range.

Current Range

The Roanoke logperch is endemic to two river systems in Virginia -- the Roanoke River drainage (including the Pigg and Smith rivers) and the Nottoway River drainage. Its range extends from the Ridge and Valley province through the Blue Ridge to the lower Piedmont. The four disjunct populations now known probably represent remnants of much larger populations that once occupied much of the Roanoke River and Nottoway River drainages upstream of the fall line. (USFWS, 1992)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: The Roanoke logperch eats mainly benthic insects often obtained after overturning stones with snout (Jenkins and Burkhead 1994). In the Roanoke River, young fed primarily on chironomid larvae; adults ate mainly caddisfly larvae and chironomids (USFWS 1991). (37.1%) and chironomids (25.5%). The Roanoke logperch is considered a diurnal, visual predator. Seeks shelter and remains inactive when water temperature falls below 8 C (Jenkins and Burkhead 1994). The feeding behavior of P. rex, noted by Burkhead (1983), consisted of flipping over stones with its snout and ingesting the exposed prey. This strategy, along with stomach content analysis, suggests that P. rex does not actively select certain taxa but consumes most food items encountered. (NatureServe, 2015)

Reproduction Narrative

Adult: The species commonly lives 5-6 years with a maximum known age of about 6.5 years (Burkhead and Jenkins 1991). Males mature in two years; most females mature in three years (Burkhead and Jenkins 1991). Spawning occurs in April or May at 12-14 C (based on ovarian development). The spawning behavior of P. rex, noted by Burkhead (1983), is similar to that of P. caprodes (Winn 1958). All Percina species typically bury their eggs, with no subsequent parental care (Page and Swofford 1984). Eggs are adhesive and demersal (Jenkins and Burkhead 1994). (USFWS, 1992; NatureServe, 2015)

Geographic or Habitat Restraints or Barriers

Adult: Intolerant of moderately to heavily silted substrata (USFWS, 1992)

Environmental Specificity

Adult: Low (USFWS, 1992)

Habitat Narrative

Adult: The Roanoke logperch occupies medium to large warm-water streams and rivers of moderate gradient with relatively unsilted substrata. Habitat use by the species varies with age, spawning condition, and seasonal temperature (Burkhead 1983) but typically includes gravel and boulder runs and in riffles, runs, and pools with sandy to boulder-strewn bottoms. (Page and Burr 2011). During different phases of life history and season, every major riverine habitat is exploited by the logperch. Males are associated with shallow riffles during the reproductive period, whereas females are common in deep runs over gravel and small cobble, which are the observed spawning areas. Young and juveniles usually occupy slow runs and pools with clean sand bottoms. Winter habitat (water temperature < 80 C) of all individuals is assumed to be under boulders in deep pools. Except in winter, all age classes are intolerant of moderately to heavily silted substrata (Burkhead 1983). (USFWS, 1992)

Dispersal/Migration

Motility/Mobility

Adult: High (inferred from USFWS, 1992)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory (NatureServe, 2015)

Dispersal/Migration Narrative

Adult: Not available.

Population Information and Trends

Population Trends:

stable or expanding and reproducing (USFWS, 2024)

Number of Populations:

8 (USFWS, 2007)

Population Size:

Unknown (NatureServe, 2015)

Population Narrative:

Based on barriers such as major dams, eight discrete populations are known (USFWS 2007). Long-term population trends indicate a decline of <50% to relatively stable, whereas short-term trends indicate a relatively stable population. The population size is unknown. (NatureServe, 2015; USFWS, 2007) Populations of Roanoke logperch are shown to be stable or expanding and reproducing (as evidenced by sustained recruitment) since the time of listing in each of the following river systems: Upper Roanoke River, Pigg River, Smith River, and Nottoway River. The number of streams where the Roanoke logperch has been observed has increased from 14 streams from the time of listing in 1989 to 31 streams in 2019 (USFWS, 2024).

Threats and Stressors

Stressor: Large dams and reservoirs (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: Perhaps the greatest overall loss of logperch habitat and reduction in this species' range occurred when construction of the Smith Mountain and Leesville Dams was completed in 1963. The construction of these hydropower dams likely destroyed over 150 km of habitat within the Piedmont section of the Roanoke River drainage. This dam construction also isolates the Pigg River and Roanoke River logperch populations. The dams increased the vulnerability of logperch to extirpation and eliminated the possibility of recolonization from downstream. On the Smith River, Philpott Dam was constructed in 1952. Upstream of the Philpott Reservoir, the stretch of occupied river is small, isolated, and therefore, vulnerable to other human impacts that affect instream habitat. Downstream of the reservoir, hydropeaking and coldwater releases render at least 8 river km unsuitable for logperch. (USFWS, 2007)

Stressor: Small dams and barriers (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: At least three smaller dams - Martinsville Dam on the Smith River, Power Dam on the Pigg River, and Niagara Dam on the upper Roanoke River - have separated populations and displaced logperch habitat. (USFWS, 2007)

Stressor: Urbanization (USFWS, 2007)
Exposure:
Response:
Consequence:

Narrative: The human population in and around the City of Roanoke area is continuing to expand. This is accompanied by the usual symptoms of watershed urbanization, including expanding impervious surfaces, increased urban sprawl, and loss of open areas and farmland. This could negatively affect all logperch populations within the Roanoke River drainage. (USFWS, 1992)

Stressor: Agriculture/forestry (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: The most widespread current threat to Roanoke logperch is non-point source pollution in the form of fine sediment from both urban and agricultural activities. Particularly in the Roanoke drainage, crop and livestock farming contributes deposits of fine sediment and silt into the upper Roanoke, Pigg, and Smith Rivers. In upstream reaches, cattle often have unrestricted access to stream channels, which often results in failing and highly eroded streambanks. (USFWS, 1992)

Stressor: Channelization (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: The morphology of rivers in the Roanoke drainage, particularly the upper Roanoke River, have been altered in many locations due to filling and small-scale channelization. The ongoing Roanoke River Flood Reduction Project could have negative impacts on the logperch population in the upper Roanoke River. The Roanoke River Flood Reduction Project will involve earth-moving activities that will likely temporarily increase sediment input into the river, and may, therefore, negatively affect the Roanoke logperch. (USFWS, 1992)

Stressor: Road building (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: Urbanization and continued economic growth have resulted in an increase in new high construction, highway improvement, and paved road projects. The Virginia Department of Transportation proposed to construct Interstate 73, which could potentially impact all populations of Roanoke logperch in the Roanoke drainage. The proposed Interstate crosses the Pigg River 3 km east of Rocky Mount, and thus the majority of Roanoke logperch in the Pigg River are downstream of the crossing, where they could be directly impacted by any chemical spills on highway or road crossings or sedimentation during and after construction. Watershed urbanization is also a substantial threat to Roanoke logperch in the Pigg River. (USFWS, 1992)

Stressor: Toxic spills (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: Limited information indicates that spills are common and should be considered a persistent threat (Burkhead 1983, USFWS, 1992, Wheeler et al. 2002). The most severe of these incidents in the logperch range occurred in the Pigg River in 1975, when an accidental discharge

of copper sulfate in Rocky Mount caused a kill of an estimated 28,704 fish over 36 km of river (James 1979). (USFWS, 1992)

Stressor: Riparian loss (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: Roanoke logperch in the Nottoway River are commonly observed in and around woody debris in low flow areas (Rosenberger and Angermeier 2002), which may serve as cover from predators and a source of food (Angermeier 1985). Wood removal practices and deforestation of the streambanks in the Roanoke River basin have greatly reduced the availability of wood in these systems due to loss of riparian vegetation and intentional debris removal in urban areas. In addition to the silt cover, the lack of woody debris in Roanoke River pools may reduce pool suitability for Roanoke logperch. (USFWS, 1992)

Stressor: Water withdrawals (USFWS, 2007)
Exposure:
Response:
Consequence:
Narrative: The Service is aware of one water withdrawal project on the Nottoway River: a titanium mining operation in Dinwiddie and Sussex Counties withdraws water for their processing facility in Sussex County. (USFWS, 1992)

Recovery

Reclassification Criteria:
1. Populations of Percina rex are shown to be stable or expanding and reproducing (as evidenced by sustained recruitment) in each of the following river systems: upper Roanoke River, Pigg River, Smith River, and Nottoway River. Achievement of this criterion will be determined by population monitoring over at least a ten-year period. (USFWS, 1992)

2. Each of the known populations is protected from present and foreseeable threats that may interfere with the species' survival. (USFWS, 1992)

Recovery Priority Number: 11C

Delisting Criteria:
1. Populations of Percina rex are shown to be stable or expanding and reproducing (as evidenced by sustained recruitment) in each of the following river systems: upper Roanoke River, Pigg River, Smith River, and Nottoway River. Achievement of this criterion will be determined by population monitoring over at least a ten-year period. (USFWS, 1992)

2. Each of the known populations is protected from present and foreseeable threats that may interfere with the species' survival. (USFWS, 1992)

3. Habitat improvement measures have been developed and successfully implemented, as evidenced by a sustained increase in logperch population size and/or length of river reach inhabited within the upper Roanoke River drainage and a similar increase in at least two of the

other three P. rex populations (Pigg River, Smith River, or Nottoway River). (USFWS, 1992)

Recovery Actions:

- Preserve present populations and presently used habitats. (USFWS, 1992)
- Search for additional populations and/or habitat suitable for enhancement or reintroduction efforts. (USFWS, 1992)
- Determine the feasibility of reestablishing the logperch in historical habitat and reintroduce where feasible. (USFWS, 1992)
- Conduct studies necessary for the species' management and recovery. Characterize the species' habitat requirements for all life history stages. Determine the viability of various subpopulations. Determine and monitor present and foreseeable threats to the species. (USFWS, 1992)
- Implement management where needed. Implement measures to reduce erosion and excessive stream sedimentation. Identify manure holding facilities within drainages supporting Roanoke logperch populations and require measures (such as berm construction and check valve installation) to prevent accidental manure spills. Minimize or eliminate other threats. (USFWS, 1992)
- Monitor population levels and habitat conditions. (USFWS, 1992)
- Periodically assess the overall success of the recovery program and recommend actions (changes in recovery objectives. Downlist, delist, continue to protect, implement new measures, other studies, etc.). (USFWS, 1992)
- Maintain and increase the health and vigor of present populations through a watershed-level conservation approach that addresses sediment loading and preserves ecological processes that provide ephemeral, seasonal, and persistent types of habitat required over logperch ontogeny.
- Evaluate the feasibility of propagating logperch and determine whether a controlled propagation and reintroduction/augmentation plan should be developed.
- Increase connectivity of Roanoke logperch populations by identifying major and minor artificial movement barriers and eliminating them when feasible. Continue to work on the removal of Power Dam on the Pigg River and the abandoned sewer line/low bridge crossings in the Roanoke River in the City of Roanoke.
- Prevent and reduce the risk of catastrophic extirpation from toxic spills through identification, evaluation, and improvement of present and proposed road crossings, agricultural, and industrial facilities.
- Survey streams with suitable habitat and continue to identify habitat that is potentially suitable for logperch reintroductions/augmentation.
- Revise the recovery plan to include measurable criteria that specifically addresses each of the relevant listing factor and incorporate currently available information about population abundance and distribution.

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Removal of Roanoke Logperch From the List of Endangered and Threatened Wildlife. Proposed Rule.

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SPECIES ACCOUNT: *Percina williamsi* (Sickle darter)

Species Taxonomic and Listing Information

Listing Status: Threatened

Physical Description

The Sickle Darter is a small, compressed fish, with a maximum total length of about 120 mm (4.7 in.) (Figure 2) (Etnier and Starnes 1993, p. 576). The species is characterized by a long, slender body and an elongated, pointed snout (Page and Near 2007, pp. 607-608). The body color is brown to olive above and white to pale yellow below. A thin black stripe extends along the top of the body from the head to the rear of the second dorsal fin. Eight to 14 black blotches extend along each side; the blotches may be fused, forming a black stripe with undulating margins. A narrow yellow stripe may be present on each side above the dark blotches; the stripe is most prominent in juveniles and small adults. The lower sides of the body are typically covered by multiple black specks. A sickle-shaped suborbital bar (or "teardrop") extends below each eye to the underside of the head. The caudal (tail) fin has a black spot at its base and a black bar extending from the spot to about the ventral edge of the caudal fin. The first dorsal fin has a dusky or black margin, followed by a clear band and a basal dusky band. The dusky band may be bordered by a narrow clear band at the base of the fin. The remaining fins are mostly clear with diffuse dark bands. (USFWS, 2020)

Taxonomy

The Sickle Darter (Percina williamsi) is a member of the Class Actinopterygii (ray-finned fishes), Order Perciformes, and Family Percidae (perches) (Etnier and Starnes 1993, pp. 18–25). It was described by Page and Near (2007, pp. 606-608), who examined geographic variation in morphology across the range of the Longhead Darter (P. macrocephala Cope) and determined that individuals from the upper Tennessee River drainage represented a distinct species (P. williamsi). Page and Near (2007, entire) based their determination on a series of scale counts and haplotype differences in the cytochrome b gene (mitochondrial DNA). The Sickle Darter's taxonomy and common name have been accepted by the scientific community, as evidenced by the species' inclusion in Page et al. (2013, pp. 142) – a list of common and scientific names of fishes from the United States, Canada, and Mexico published by the American Fisheries Society (7th edition). (USFWS, 2020)

Historical Range

The species' historical range (prior to 2005) included nine tributary systems of the upper Tennessee River drainage in North Carolina, Tennessee, and Virginia: Emory River, Clinch River, Powell River, Little River, French Broad River, North Fork Holston River, Middle Fork Holston River, South Fork Holston River, and Watauga River (Figure 6, Table 2) (Menhinick et al. 1974, p. 42; Page 1984, pp. 659-660; Etnier and Starnes 1993, p. 576; Page and Near 2007, pp. 608-609). Jordan (1890, pp. 142-147) provided the first records of the species during explorations of the Allegheny region of North Carolina, Tennessee, and Virginia in the summer of 1888. Jordan (1890, pp. 142-147) reported a single specimen of the Sickle Darter from the Middle Fork Holston River at Glade Spring (Smyth County, Virginia) and three specimens from the North Fork Holston River at Saltville (Smyth County, Virginia). Evermann and Hildebrand (1914, p. 448) provided an additional early record in 1893–a single specimen collected from Indian Creek, a tributary of the Powell River in Claiborne County, Tennessee. Additional surveys conducted between 1894 and 2004 produced records from 12 additional streams (Table 2). The greatest number of historical occurrence records are available from the Emory River (Morgan County, Tennessee) and Little River (Blount County, Tennessee) systems. (USFWS, 2020)

Current Range

The Sickle Darter continues to occupy portions of the Emory River system (Tennessee), the upper Clinch River system (Copper Creek, Virginia), the Little River system (Tennessee), the North Fork Holston River system (Virginia), and the Middle Fork Holston River system (Virginia) (Figure 7) (Alford 2019, pp. 6-13; CFI and TDEC unpublished data). The species appears to be most abundant, with evidence of reproduction and recruitment, in the Emory River system (Morgan County, Tennessee) and Little River system (Blount County, Tennessee). The species likely occurs in low densities in Copper Creek (upper Clinch River), where recent records consist of a single specimen observed by CFI in 2008 (CFI unpublished data). Records of the species in the Middle Fork Holston River and North Fork Holston River are also rare, consisting of 11 occurrences since 2005 (Alford 2019, p. 26; CFI and TVA unpublished data). In 2014, TVA biologists discovered a single specimen of the Sickle Darter in the Sequatchie River, Bledsoe County, Tennessee – a new collection site and range extension for the species (Alford 2019, p. 2; TVA unpublished data). In 2019, Alford (2019, p. 6) confirmed the species' presence in the Sequatchie River, observing another specimen at the site. (USFWS, 2020)

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Food Source

Adult: Opportunistic

Food/Nutrient Narrative

Adult: Sickle Darters feed primarily on larval mayflies (i.e., families Baetidae and Heptageniidae) and midges (family Chironomidae); minor prey items include riffle beetles (family Elmidae), caddisflies (family Hydropsychidae), dragonflies (family Gomphidae), and several other groups of aquatic macroinvertebrates (Page and Near 2007, pp. 609-610; Alford 2019, p. 10). Crayfishes have been reported as a common food item for the closely related Longhead Darter (Page 1978, p. 663); however, crayfishes were absent from 28 gut samples of the Sickle Darter examined by Alford (2019, p. 10). The long snout and large mouth of the Sickle Darter likely facilitates the capture and ingestion of larger prey items such as heptageniid mayflies (Page and Near 2007, p. 609). Etnier and Starnes (1993, p. 576) observed Sickle Darters in the Little River deftly plucking food items from the surfaces of stones and other underwater objects while swimming above the stream bottom (USFWS, 2020).

Reproductive Strategy

Adult: Oviparity

Lifespan

Adult: >2 years

Breeding Season

Adult: February-March (USFWS, 2020)

Key Resources Needed for Breeding

Adult: water temperature 10-16 degrees C. Gravel riffles.

Other Reproductive Information

Adult: Alford (2019, pp. 7-8, 23) identified multiple size-classes and age groups across the Sickle Darter's range. Approximate age groups and size classes included age 0 (≤40 mm TL), age 1 (59-85 mm TL), and age 2+ (> 85 mm TL). Page (1978, pp. 662-223) reported three possible age groups for 148 Longhead Darters collected from the Green River, Kentucky, but ages of larger specimens (age 1+) were uncertain because scale annuli were not discernible on most specimens and direct aging of bony structures was not possible. The observed sex ratio of Longhead Darters in the Green River was 1.5 male: 1.0 female, but this ratio could be an artifact of sampling bias (Page 1978, pp. 662-663). Similar to the Longhead Darter, sexually maturity of males occurs at the end of the first year of life (age 11-13 months), while sexual maturity of females occurs at the end of their second year of life (age 22-25 months) (Page 1978, p. 663; Petty et al. 2017, p. 3). Male Sickle Darters tend to be larger than females of the same age (USFWS, 2020).

Reproduction Narrative

Adult: The species migrates to shallow, gravel shoals (riffles) in late winter or early spring (February-March) to spawn (Figure 4) (Etnier and Starnes 1993 p. 576). Spawning begins when stream water temperatures reach 10-16°C (Table 1) (Petty et al. 2017, p. 3). Breeding males darken in coloration enough to obscure their body pattern, while breeding females may darken without obscuring body pattern. In the Emory River system, Tennessee, Page and Near (2007, p. 609) collected reproductive male and female specimens from a riffle at a depth of 25 cm (10 in) and at a temperature of 8o C (46.4o F). The mature ova of the female equaled 27% of her body mass, and 100 of the 355 mature ova had a mean diameter of 1.62 mm (0.06 in). In the Little River system, Tennessee, eggs laid in March hatched in 27 days at an average stream temperature of 10o C (50o F), with larvae emerging at a length of 10 mm (0.4 in) (Etnier and Starnes 1993, p. 576). The incubation period is likely shorter (about two weeks) when stream temperatures are higher (Service 2020, p. 1). Similar to the Longhead Darter, the pelagic larvae presumably feed on zooplankton and other small macroinvertebrates after depleting yolk sac nutrients (Etnier and Starnes 1993, p. 576; Petty et al. 2017, p. 3). The pelagic larvae become demersal (move to the stream bottom) in about 30 days (USFWS, 2020).

Habitat Type

Adult: Riverine

Geographic or Habitat Restraints or Barriers

Adult: Impoundments/Dams (USFWS, 2020)

Spatial Arrangements of the Population

Adult: Linear (USFWS, 2020)

Environmental Specificity

Adult: High (inferred from USFWS, 2020)

Habitat Narrative

Adult: The Sickle Darter typically occurs in slow flowing pools (mean velocities of 6-7 cm/s (0.20-0.23 ft/s)) of larger, upland creeks and small to medium rivers (Page 1983, p. 37; Kuehne and Barbour 1983, p. 37; Etnier and Starnes 1993, p. 576; Page and Near 2008, p. 609; Alford 2019, p. 8) (Figure 3). Occupied streams tend to have good water quality, with low turbidity and negligible siltation (Etnier and Starnes 1993, p. 576; Alford 2019, p. 9). In these habitats, the species is most often associated with clean sand-detritus or gravel-cobble-boulder substrates, stands of American Water Willow (Justicia americana), or woody debris piles at depths ranging from 0.4- 1.0 m (1.3-3.3 ft) (Etnier and Starnes 1993, p. 576; Page and Near 2008, p. 609; Alford 2019, p. 8). Alford (2019, p. 10) observed Sickle Darters most often in shallow pools near the bank or adjacent to vegetated gravel bars, but these pools were always adjacent to swift currents. Streams supporting Sickle Darters had wetted widths ranging from 9-33 m (29.5-108.3 ft), and riparian canopy cover in these streams ranged from open (41%) to nearly closed (91%) (Alford 2019, p. 8). The species spends most of its time in the water column, often hovering a few centimeters (inches) above the stream or river bottom (Etnier and Starnes 1993, p. 576). The prominent black stripe or series of blotches along the side of P. williamsi is characteristic of darters living near vegetation in flowing pools (USFWS, 2020).

Dispersal/Migration

Dispersal

Adult: Dispersal is limited by dams/impoundments

Population Information and Trends

Population Trends:

Decreasing (inferred from USFWS, 2020).

Number of Populations:

6 (USFWS, 2022)

Population Size:

largest population size estimated to be 1,400-3,500 (Emory River system) (USFWS, 2020).

Additional Population-level Information:

estimated a population size of 1,400-3,500 Sickle Darters in the Emory River system. estimated a population size of 420-1,050 Sickle Darters in the Little River system. Population estimates were not calculated for other systems due to the low abundance in those systems (< 10 individuals observed since 2005) (USFWS, 2020).

Population Narrative:

Currently, the Sickle Darter is known from six tributary systems in the Tennessee River drainage – Emory River, Little River, Clinch River, North Fork Holston River, Middle Fork Holston River, and Sequatchie River. Historical populations in the Powell River, French Broad River, South Fork Holston River, and Watauga River systems are now considered to be extirpated. Impoundments and water pollution were major factors in the Sickle Darter's decline during the early to mid-

20th Century. Current factors include habitat and water quality degradation, low connectivity, and small population size (e.g., Clinch River). We consider the Emory River and Little River populations to exhibit moderate resiliency, as evidenced by the species' persistence within these systems for over 45 years, recent and repeated evidence of reproduction and recruitment, a relatively long occupied reach in each system (> 22.5 km (> 14 mi)), and the quality of physical habitat and water quality in both systems. We consider the remaining four populations to exhibit low resiliency. They are represented by fewer documented occurrences, no evidence of recruitment, shorter occupied reaches, and they occur in habitats with limited habitat and water quality. The species' representation is low because of its reduced range (i.e., a loss of genetic diversity) and a loss of connectivity caused by dam construction. The Sickle Darter occupies only two of three historical ecoregions (Ridge and Valley and Southwestern Appalachians), likely reducing its ability to adapt to changing environmental conditions over time. The species' redundancy is low based on the number of resilient populations and the amount of isolation observed across the species' range. This increases the species' vulnerability to stochastic disturbance and catastrophic events. (USFWS, 2020)

Threats and Stressors

Stressor: Siltation (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative:

Stressor: Water Quality Degradation (Pollution) (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative:

Stressor: Impoundments – Habitat Fragmentation and Loss (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative:

Stressor: Reduced Range (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative:

Stressor: Climate Change (USFWS, 2020)
Exposure:
Response:
Consequence:
Narrative:

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2020. Sickle Darter (Percina williamsi) Species Status Assessment, Version 1.0. March 2020. Atlanta, Georgia. 87 pp.

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SPECIES ACCOUNT: *Plagopterus argentissimus* (Woundfin)

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 10/13/1970, 07/24/1985; Mountain-Prairie Region (R6) (USFWS, 2016)

Physical Description

Woundfin is a small slender, silvery minnow, with a flattened head and belly, long snout, leathery skin, and no scales. There are barbels on the corners of its lips, and its common name likely comes from the first spinous ray of its dorsal fin, which is sharp-pointed. Its maximum length is rarely more than 7.5 cm (3 in). It can be distinguished from spikedace and spinedace by presence of barbels. Males are slightly larger than females, and their appearance does not change seasonally. Adolescent woundfin are smaller than adults but look similar.

Taxonomy

The full classification of the Woundfin is: Animalia chordata actinopterygii cypriniformes cyprinidae plagopterus argentissimus. It is the only member of its Genus, Plagopterus.

Historical Range

Historical range included the Colorado and Gila river basins in Arizona, Nevada, and Utah, including at least the Colorado River from Yuma upstream into the Virgin River in Nevada and Utah, and the Gila River from Yuma to the confluence of the Salt River. No barriers or habitat considerations would have limited the species to this specific area, so it is likely that the historical range extended farther upstream in the Verde, Salt, and Gila rivers in Arizona (USFWS 2000).

Current Range

U.S.: Gila, Graham, Greenlee, Maricopa, Mohave, and Yavapai counties, AZ; occurrences along Gila River drainage, New Mexico; Clark County, NV; Washington County, UT. Preliminary sampling results collected in 2007 indicated that the wild woundfin population was functionally extirpated throughout its designated critical habitat (140 stream-kilometers along the Virgin River) (USFWS 2008). Hatchery-raised woundfin have been stocked in the upper Virgin River, and additional releases are planned in the future. In 1972, woundfin were transplanted into four locations in the Gila River system, but populations were not established (USFWS 2008). In 1985, streams in the Gila River drainage (Hassayampa, Verde, San Francisco, and Gila rivers, and Tonto Creek) were identified as reintroduction sites, and the Gila River drainage was designated as a nonessential experimental population. Reintroduction efforts in the Gila River drainage in Arizona are underway (USFWS 2008).

Distinct Population Segments Defined

No.

Critical Habitat Designated

Yes; 1/26/2000.

Legal Description

On January 26, 2000 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Plagopterus argentissimus (Woundfin) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Arizona, Nevada and Utah (65 FR 4140-4156).
The critical habitat designation for Plagopterus argentissimus includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Plagopterus argentissimus.

Critical Habitat Designation

The critical habitat designation for Plagopterus argentissimus includes one CHU in Washington County, Utah; Mohave County, Arizona; and Clark County, Nevada (65 FR 4140-4156).

Utah, Washington County; Arizona, Mohave County; Nevada, Clark County - The Virgin River and its 100-year floodplain from its confluence with La Verkin Creek, Utah in T.41S., R.13W., sec.23 (Salt Lake Base and Meridian) to Halfway Wash, Nevada T.15S., R.69E., sec.6 (Salt Lake Base and Meridian).

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Plagopterus argentissimus critical habitat consists of nine components (65 FR 4140-4156):

(1) Water—A sufficient quantity and quality of water (i.e., temperature, dissolved oxygen, contaminants, nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is identified for the particular life stage for each species. This includes the following: 1. Water quality characterized by natural seasonally variable temperature, turbidity, and conductivity;

(2) hydrologic regime characterized by the duration, magnitude, and frequency of flow events capable of forming and maintaining channel and instream habitat necessary for particular life stages at certain times of the year; and

(3) flood events inundating the floodplain necessary to provide the organic matter that provides or supports the nutrient and food sources for the listed fishes.

(4) Physical Habitat—Areas of the Virgin River that are inhabited or potentially habitable by a particular life stage for each species, for use in spawning, nursing, feeding, and rearing, or corridors between such areas: 1. River channels, side channels, secondary channels, backwaters, and springs, and other areas which provide access to these habitats;

(5) 2. areas inhabited by adult and juvenile woundfin include runs and pools adjacent to riffles that have sand and sand/gravel substrates;

(6) 3. areas inhabited by juvenile woundfin are generally deeper and slower. When turbidity is low, adults also tend to occupy deeper and slower habitats;

(7) 4. areas inhabited by woundfin larvae include shoreline margins and backwater habitats associated with growths of filamentous algae.

(8) Biological Environment—Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although considered normal components of this environment, are out of balance due to nonnative fish species in many areas. Fourteen introduced species, including red shiner (Cyprinella lutrensis), black bullhead (Ameiurus melas), channel catfish (Ictalurus punctatus), and largemouth bass (Micropterus salmoides), compete with or prey upon the listed fishes. Of these, the red shiner is the most numerous and has been the most problematic for the listed fishes. Red shiners compete for food and available habitats and are known to prey on the eggs and early life stages of the listed fishes. Components of this constituent element include the following: 1. Seasonally flooded areas that contribute to the biological productivity of the river system by producing allochthonous (humus, silt, organic detritus, colloidal matter, and plants and animals produced outside the river and brought into the river) organic matter which provides and supports much of the food base of the listed fishes; and

(9) 2. few or no predatory or competitive nonnative species in occupied Virgin River fishes' habitats or potential reestablishment sites.

Life History

Feeding Narrative

Juvenile: Woundfin are omnivores that consume vegetation, detritus, arachnids, and insects (Greger and Deacon 1987 pp. 74-75, USFWS 1994 p. 7). Shifts in food selectivity are attributed to geographic location and availability of food resources (Greger and Deacon 1988 p. 318, USFWS 1994 p. 7). Common vegetation ingested includes filamentous algae and tamarisk seeds (Greger and Deacon 1988 p. 318, USFWS 1994 p. 7). Common insect prey items include mayflies, as well as larval and adult forms of species in the true fly family, such as biting and non-biting midges (Greger and Deacon 1988 p. 318, USFWS 1994 p. 7).

Adult: Woundfin are omnivores that consume vegetation, detritus, arachnids, and insects (Greger and Deacon 1987 pp. 74-75, USFWS 1994 p. 7). Shifts in food selectivity are attributed to geographic location and availability of food resources (Greger and Deacon 1988 p. 318, USFWS 1994 p. 7). Common vegetation ingested includes filamentous algae and tamarisk seeds (Greger and Deacon 1988 p. 318, USFWS 1994 p. 7). Common insect prey items include mayflies, as well as larval and adult forms of species in the true fly family, such as biting and non-biting midges (Greger and Deacon 1988 p. 318, USFWS 1994 p. 7).

Reproduction Narrative

Adult: Wouldfin spawn over gravel to cobble sized substrate (USFWS 1994 p. 7). This substrate allows allows the adults to deliver the adhesive eggs to the interstiatial spaces of the substrate (Greger and Deacon 1982 p. 551). It is thought that a combination of decreased water flows following peak spring flow (descending limb of the hydrograph), water temperatures, and lengthening daylight combine to initiate woundfin spawning (USFWS 1994 p. 7, USFWS 2000 p. 4141). Spawning occurs during April to July, depending on the timing of run-off from snowmelt

(Cross 1978 p. 465, USFWS 1994 p. 7). Early spawning may occur in protected coves and late spawning downstream as a result of late season thunderstorms (USFWS 1994 p. 7). Additionally, a natural hydrologic regime that includes periods of high discharge aid in limiting the expansion and competition with non-native predators (Deacon 1988 p. 22). Spawning in artificial stream systems occured in depth ranging from 0.07 to 0.10 m (USFWS 1994 p. 8). Gravid females congregate in in deeper water adjacent to riffle habitat prior to spawning (Gregor and Deacon 1982 p. 551, USFWS 1994 p. 7, USFWS 2000 p. 4145). When ready to spawn, the female will leave the deeper water and join a group of males in shallow, swift water (Greger and Deacon 1982 p. 551, USFWS 1994 p. 7). In captivity, most spawn the second spring after hatching; most survive two reproductive seasons (see Minckley and Deacon 1991). The lifespan of the wouldfin is apparently seldom, if ever, more than 4 years.

Geographic or Habitat Restraints or Barriers

Adult: Dams lacking a suitable fishway; high waterfall; upland habitat. For some species (e.g., slender chub), an impoundment may constitute a barrier; the presence of nonnative fishes, particularly the red shiner (Cyprinella lutrensis)

Environmental Specificity

Adult: Benthic

Tolerance Ranges/Thresholds

Adult: Preferred water temperature 18°C; critical thermal maximum is between 30.49 and 39.26°C; water depths of 0.15-0.43 meters; water velocities of 0.24-0.49 meters per second.

Habitat Narrative

Egg: Deposited eggs adher to the interstitial spaces of gravel to cobble substrate (Gregor and Deacon 1982 p. 551).

Larvae: Woundfin larvae utilize habitats with low-velocity water flow (USFWS 1994 p. 5). This habitat is usually found in backwaters and along the stream margins (USFWS 1994 p. 5, USFWS 2000 p. 4141). In an experimental stream, Gregor and Deacon (1982 p. 551) observed that larvae are found in lower velocity water that ranged between 0.01 - 0.03 m/sec. This low velocity may allow the larvae to develop while not exceeding the larvae's swim capability. Larval woundfin habitat is strongly associated with dense growths of filamentous algae (USFWS 1994 p. 5, USFWS 2000 p. 4141). Algae may provide the larvae shelter from predators.

Juvenile: Woundfin larger than 4 cm are generally found over sand or sand and gravel substrates (Cross 1978 p. 464, Williams 1995 p. 1, USFWS 1994 p. 5, USFWS 2000 p. 4141). Adults are generally found in habitats with water depths of 0.15-0.43 meters and velocities of 0.24-0.49 meters per second, whereas juveniles select areas with slower and deeper water, and larvae are found in backwaters and stream margins which are often associated with growths of filamentous algae (USFWS 2000).

Adult: Water temperature effects the function and behavior of the species. The critical thermal maxima for the species ranges between 30.49 - 39.26°C, depending on environmental conditions (Deacon et al. 1987 p. 540). When water temperatures approach 30°C, the species tends to move to deeper cooler water (USFWS 1994 p. 5). Additionally, the preferred water temperature for the species is approximately 18°C (Deacon et al. 1987 p. 543, USFWS 1994 p. 5);

preferred water depths are 0.15-0.43 meters; water velocities of 0.24-0.49 meters per second are preferred by adults.Woundfin larger than 4 cm are generally found over sand or sand and gravel substrates (Cross 1978 p. 464, Williams 1995 p. 1, USFWS 1994 p. 5, USFWS 2000 p. 4141). They spawn over gravel to cobble sized substrate (USFWS 1994 p. 7). This substrate allows allows the adults to deliver the adhesive eggs to the interstiatial spaces of the substrate (Greger and Deacon 1982 p. 551). Barriers may include dams lacking a suitable fishway, high waterfalls; and upland habitat; the presence of nonnative fishes, particularly the red shiner (Cyprinella lutrensis). For some species (e.g., slender chub), an impoundment may constitute a barrier.

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: Local migrant

Dispersal

Adult: Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats.

Dispersal/Migration Narrative

Adult: Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats. The woundfin appears to undertake relatively long migrations within present habitat (Lee et al. 1980). NatureServe 2015.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

Unknown

Number of Populations:

1 to 5, but only 1 if the Virgin River is regarded as a single metapopulation

Population Size:

Unknown

Minimum Viable Population Size:

Unknown

Resistance to Disease:
Unknown

Adaptability:
Unknown

Population Narrative:
Historical range included the Colorado and Gila river basins in Arizona, Nevada, and Utah, including at least the Colorado River from Yuma upstream into the Virgin River in Nevada and Utah, and the Gila River from Yuma to the confluence of the Salt River. No barriers or habitat considerations would have limited the species to this specific area, so it is likely that the historical range extended farther upstream in the Verde, Salt, and Gila rivers in Arizona (USFWS 2000).When the woundfin was listed in 1970, they occupied 12.5% of their historical range. Thirty years later the USFWS designated that portion of historical range (87.5 miles of the Virgin River) as critical habitat. In the past 20 years, woundfin have been eliminated from at least 35 miles of critical habitat in the lower river and abundance has declined to precariously low levels elsewhere. Preliminary sampling results collected in 2007 indicated that the wild woundfin population was functionally extirpated throughout its designated critical habitat (140 stream-kilometers along the Virgin River) (USFWS 2008). Hatchery-raised woundfin have been stocked in the upper Virgin River, and additional releases are planned in the future. In 1972, woundfin were transplanted into four locations in the Gila River system, but populations were not established (USFWS 2008). In 1985, streams in the Gila River drainage (Hassayampa, Verde, San Francisco, and Gila rivers, and Tonto Creek) were identified as reintroduction sites, and the Gila River drainage was designated as a nonessential experimental population. Reintroduction efforts in the Gila River drainage in Arizona have been underway (USFWS 2008). The area of occupancy for wouldfin includes only part of a 140-kilometer section of the Virgin River. Reintroduced occurrences in the Gila River cannot yet be counted as being occupied by established populations. This species is represented by very few occurrences (~ 5 subpopulations) (only one if the Virgin River is regarded as a single metapopulation). The total adult population size is unknown. Distribution and abundance have declined over the past 10 years or 3 generations 3 generations is roughly 10 years). In the past 20 years, woundfin have been eliminated from at least 56 kilometers of designated critical habitat in the lower Virgin River, and abundance has declined to precariously low levels elsewhere (USFWS 2008). Surveys in the early 1970s found that the woundfin was the most common native species, comprising about half (5,000 of 10,822) of the native fish collected (Cross 1978). It has declined greatly since then, with increases in the range and abundance of the red shiner. The species now occupies not more than 12 percent of the estimated historical range (USFWS 2000). Over the past 30 years, woundfin have generally declined throughout their occupied range and critical habitat. They have been extirpated from the Lower Virgin River (i.e., from Beaver Dam Wash, perhaps from the Utah / Arizona State line, downstream to Lake Mead). Populations in Utah, particularly those upstream of the influence of red shiner (i.e., upstream of the Washington Fields Diversion), have persisted better than anywhere else (USFWS 2008).

Threats and Stressors

Stressor: Habitat modification degradation
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.

Consequence: Not assessed; see narrative.
Narrative: Reduced base flows are of concern and likely threaten woundfin to varying degrees throughout designated critical habitat. The effects of reduced flows, sediment sluicing (release of sediment build-up), exacerbated by the severe and persistent drought in recent times (the lowest Virgin River flows on record occurred in 2002), have negatively affected woundfin and other native species throughout the Virgin River. An unquantified, but real threat to the Virgin River fish is their entrainment at water diversion structures throughout the Virgin River system that have the capability to dry-dam the river.

Stressor: Nonnative species
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Introduction and establishment of nonnative fish in western rivers of the USA is a major threat to conservation of native fish assemblages (Minckley and Deacon 1968, Stanford and Ward 1986, Moyle et al. 1986, Carlson and Muth 1989, Minckley and Deacon 1991, Olden et al. 2006). The introduction of nonnative fish species, in particular the red shiner, has had detrimental impacts on native fish populations in the Virgin River system. Note: Predation of juvenile or adult fish also are likely a factor, especially when the fish are in limited thermal refuges concentrated in with centrarchids and catfish. This is probably most problematic in the lower river where there are smaller pools and any cover is dominated by predatory nonnative fish. Negative interactions between native species and small bodied nonnatives (red shiner, sand shiner (Notropis straminues), and fathead minnow (Pimephales promelas)) have been documented throughout the Colorado River basin (Haines and Tyus 1990, Rupert et al. 1993, Propst and Gido 2004). Resulting declines in woundfin numbers are caused by predation of young of year, competition for habitat and food resources, and introduction of parasitic organisms (Heckman et al. 1986).

Recovery

Reclassification Criteria:
Development and implementation of operational criteria for existing dams, reservoirs, and diversions that provide for flows sufficient to sustain all life stages near historic levels of abundance; acquisition of priority water rights to ensure instream flows of sufficient water quality and quantity from Pah Tempe Springs downstream to Lake Mead to ensure the species' survival; and agreements to ensure passage, timing, and magnitude of flows necessary for channel maintenance during appropriate periods of the year.

Degraded Virgin River habitats from Pah Tempe Springs to Lake Mead are improved and maintained to allow continued existence of all life stages at viable population levels.

Barriers to upstream movements of introduced fishes are established, and red shiners and other nonnative species that present a major threat to the continued existence of the native fish community are eliminated upstream of those barriers.

Delisting Criteria:
Delisting criteria for the woundfin are considered interim because the opportunity and the potential locations for re-establishment of additional populations are uncertain. Two additional

self-sustaining populations are established in the wild within its historical range. This will require that adequate protection of available habitat and instream flows are maintained, the populations have been self-sustaining for a minimum of 10 consecutive years, and a plan for genetic exchange between the populations has been developed and implemented. Quantitative criteria and timeframes for defining self-sustaining in more detail will be determined as more information becomes available.

Essential habitats, important migration routes, required stream flow, and water quality of both the Virgin River habitat and the habitat of transplanted populations are legally protected, and the threats of other significant physical, chemical, or biological modification such that the habitat would become unsuitable for the woundfin are removed.

Recovery Actions:

- Upstream of Washington Fields Diversion to Pah Tempe Springs, base flows must be augmented to provide the flows and temperatures needed to assist in the recovery of the woundfin.
- In the short term, provide flows below the Washington Fields Diversion in a quantity that assists in the recovery of the Virgin River fish. In the long term, provide flows in a quantity that assist in recovery of the Virgin River fish throughout critical habitat.
- Continue to coordinate with State and Local governments in the development and implementation of floodplain and erosion zone ordinances throughout the Virgin River drainage.
- Complete construction of a proposed nonnative fish barrier in the Virgin River Gorge in Arizona by the fall of 2008; extend Virgin River Program red shiner eradication.
- Implement an effective nonnative control strategy downstream of the Virgin Gorge Barrier by autumn 2009.
- Complete construction of a proposed nonnative fish barrier in the lower Virgin River in Nevada by spring 2010.
- Prior to the next 5-year review, the USFWS should coordinate with State wildlife management agencies to develop a strategy to prevent further invasions of nonnative aquatic species (fish and mollusks) throughout the Virgin River drainage.
- Implement the proposed VRHCRP within 18 months of the signing of this 5-year review. A coordinated and consistently funded recovery effort in the lower river, as budgets allow, is required to compliment the activities of the Virgin River Program in the upper river.
- Work with stakeholders in Arizona to partner with the Virgin River Program, and with the VRHCRP when established, to fully incorporate occupied, and federally designated Critical Habitats into coordinated recovery actions.
- Not developed.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS The continued persistence of woundfin and Virgin River chub will require the active management of populations and habitat conditions for the foreseeable future. The VRP has successfully led the implementation of conservation and recovery measures in the upper Virgin River Basin. The VRP provides a vehicle for adaptive broad-based collaborative management between local, state, and Federal interests and resource agencies. The persistence and recovery of woundfin and Virgin River chub is contingent on maintaining communication and cooperation between these interests. Secure funding for the VRP and its signatory partners is imperative to continue recovery actions in the current range of woundfin and Virgin River chub. A similar collaborative management effort needs to extend downstream through the lower Virgin River in Arizona and Nevada. Human population growth and associated development has escalated in the Virgin River Basin in the last 25 years. The area has rapid population growth and increasing demands on the Virgin River system for water use. Providing instream flows to address high water temperatures and maintain adequate habitat and management of nonnative fishes is critical for the recovery of woundfin and Virgin River chub. Adaptive management is necessary to monitor Virgin River fish status, rapidly implement conservation actions, evaluate population response to those actions, and respond proactively to exploit recovery opportunities. Based on the current status of woundfin and Virgin River chub, the primary recommendations for recovery include protecting and enhancing woundfin and Virgin River chub populations within their current distribution, and expanding the range of woundfin and Virgin River chub to ensure redundancy and resiliency. Actions to protect and enhance current woundfin and Virgin River chub populations continue to be implemented through the VRP. Basinwide recovery priorities for woundfin and Virgin River chub are identified and evaluated annually by the Recovery Team. Recovery actions are then implemented by the VRP and lower basin partners. Progress on those actions are reviewed annually and modified as necessary. The recovery of woundfin and Virgin River chub requires expanding populations and increasing occupied geographic range. Establishing viable populations in the Virgin River downstream of the WFD increases population resiliency and significantly decreases vulnerability. Woundfin and Virgin River chub populations remain vulnerable to both stochastic and catastrophic events within their current limited geographic distribution. Eradication of red shiner and establishing populations downstream of the WFD remains the highest priority for recovery of both species. Although significant progress has been achieved since 2000, it is imperative to continue downstream red shiner eradication to facilitate recovery of woundfin and Virgin River chub. Following red shiner eradication, a fish barrier on the lower Virgin River is critical to prevent recolonization of the Virgin River by red shiner and other nonnative fish from Lake Mead. In addition, establishing a stable, reproducing woundfin population upstream of the QCD would increase distribution and significantly enhance its ability to withstand drought periods and episodic water quality events. The Virgin River mainstem above the QCD has largely natural flow conditions with protected base flows, unregulated high flow events, sediment transport, and channel forming/habitat maintenance flows. Although, it is unknown whether woundfin will persist in the Virgin River upstream of the QCD, water temperatures during summer baseflow periods are less extreme and are likely to support woundfin survival and recruitment. It may also provide an upstream source capable of supplementing the woundfin population between Ash Creek and WFD. Finally, a stable reproducing woundfin population upstream of the QCD would increase distribution and significantly enhance woundfin populations within their current range. A viable upstream population would achieve redundancy and resiliency by significantly enhancing the species ability to withstand drought periods, episodic water quality events, and other stochastic and catastrophic events. To ensure redundancy and resiliency, woundfin and Virgin River chub populations need to be reestablished throughout the Virgin River from Johnson Diversion downstream into Arizona and Nevada. First, the downstream eradication of red shiner will need to continue. This will require ongoing cooperation between Recovery Team partners in the upper and lower Virgin River. To ensure eradication success, permanent fish barriers need to be constructed to prevent red shiner recolonization. Once this is accomplished, native fish will need to be reestablished in the lower Virgin River. To facilitate recovery, additional factors limiting recruitment and survival of native fish populations will need to be evaluated and addressed on a reach by reach basis (e.g., nonnative fish, instream temperature and flow, water quality). Conservation actions to remove limiting factors and establish viable populations of woundfin and Virgin River chub must then be implemented (e.g., control smallmouth bass and red shiner, mitigate high instream temperatures, increase instream flows, protect riparian habitat). In addition, we recommend evaluating the status of the Muddy River population of Virgin River chub and, if warranted, including the population into a revised recovery strategy and criteria. Recommendations to address population resiliency, redundancy, and representation are summarized below for woundfin (Table 4) and Virgin River chub (Table 5). (USFWS, 2020)

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Designation of Critical Habitat for the Woundfin and Virgin River Chub

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SPECIES ACCOUNT: *Poeciliopsis occidentalis* (Gila topminnow (incl. Yaqui))

Species Taxonomic and Listing Information

Listing Status: Endangered; March 11, 1967; Southwest Region (R2)

Physical Description

A small (2.5-5 cm), silvery, live-bearing, guppy-like fish without dark spots on the fins. Males in breeding color are black with yellow fins. There are two listed subspecies of the Sonoran topminnow (P. occidentalis); the Gila topminnow (P. o.occidentalis) of the Gila River basin and the Yaqui topminnow (P.o. sonoriensis) of the Rio Yaqui.

Taxonomy

The species was originally described by Baird and Girard (1853) as Heterandria occidentalis from a specimen collected in 1851 from the Santa Cruz River near Tucson. It was redescribed by Hubbs and Miller (1941) as P. occidentalis.

Historical Range

One of the most common fish found throughout the Gila River drainage in Arizona. Also extended into Mexico and New Mexico.

Current Range

U.S.: Cochise, Gila, Graham, Maricopa, Pima, Pinal, Santa Cruz, and Yavapai counties, AZ; Grant and Hidalgo counties, NM.

Distinct Population Segments Defined

No.

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Gila topminnows are opportunistic omnivorous feeders. Primary food items include detritus, vegetation, amphipods, ostracods, and insect larvae; and rarely, other fishes (Schoenherr 1974; Gerking and Plantz 1980; Meffe et al. 1983; Meffe 1984), although they will prey on their own young. . Gerking and Plantz (1980) noted that Gila topminnows prefer to eat large prey, but prey sizes are limited by mouth size. Schoenherr (1974) observed that individual fishes in complex habitats with several food resources present would select and focus on different items. He suggested that variation in feeding among individuals prevents over-utilization of a single resource, enhancing survival potential of the species by making it independent of that resource.They will prey on their own young. Dense mats of algae and debris along the margins of the habitats are an important component for foraging. Substrates of organic muds and detritus also provide foraging areas.

Reproduction Narrative

Adult: Gila topminnows are viviparous fish, meaning embryos grow and mature within the female and are born living. Eggs are fertilized internally through deposition of spermatophores (packets of sperm) into the female's genital pore by the male's gonopodium. Female Gila topminnow can store spermatozoa for several months, and may produce up to 10 broods after being isolated from males (Schultz 1961). Female Gila topminnows also exhibit superfetation in which two or more groups of embryos develop simultaneously at different stages. Females of the genus Poeciliopsis generally carry only two stages, although some P. occidentalis females have been shown to carry three for a few days when population densities are low. Mean intervals between broods is 21.5 days (Schoenherr 1974). Brood size ranges from 1-31 dependant upon female SL (Constantz 1974; Schoenherr 1974, 1977). Under optimum laboratory conditions, Poeciliopsis can produce 10 broods per year at intervals of 7-14 days (Schultz 1961). Sexual maturity can be attained as early as 2 months or as late as 11 months following birth, dependant upon the season of birth (Schultz 1961; Constantz 1976, 1979; Schoenherr 1974). Females from Monkey Spring as small as 22 mm standard length, indicating an age of approximately 4 months, were sexually mature (Schoenherr 1974). Males begin gonopodial development at around 17 mm SL with most reaching maturity between 22-24 mm SL, at about 4 months. Breeding occurs primarily during January through August, but in thermally constant springs young may be produced throughout the year (Heath 1962; Minckley 1973; Schoenherr 1974). During the peak of the breeding season up to 98% of mature females are pregnant (Minckley 1973). Dominant males (14-25 mm SL) turn black, defend territories, and court females. Smaller subordinate males do not turn black or defend territories. Instead, they take on a "sneaking" mating strategy where they attempt to mate with uncooperative females while the dominant male is busy elsewhere. Subordinate males have a longer gonopodium, which may have an adaptive benefit for this type of mating strategy (Constantz 1989). However, if the larger territorial males are removed, smaller males will become dominant, take on breeding coloration, and defend territories (Constantz 1975; Schoenherr 1977). Brood size and the onset of breeding in topminnows can be influenced by several factors including food abundance, photoperiod, temperature, predation upon the population, and female size. Increased food supply and larger female size are believed to contribute to the greater fecundity seen in topminnows from Monkey Spring canal compared with topminnows from Monkey Spring headspring (Constantz 1974, 1979; Schoenherr 1974, 1977). Sex ratios in stabilized populations nearly always favor females, varying from 1.5 to 6.3 per male (Schoenherr 1974). However, Schultz (1961) and Schoenherr (1974) both showed that ratios at birth approximated 1.0. These different ratios can be explained two ways; by females living longer, or as indicated by Krumholz (1948), by males being less hardy than females. Mortality during transportation for reintroduction purposes has been observed to be higher for males than females, indicating sexual differences in ability to handle stress. Differences in sex ratios can be observed in populations depending on season of sampling, predation effects, or sampling technique biases.

Geographic or Habitat Restraints or Barriers

Adult: Limited connectivity by dams and water diversions

Environmental Specificity

Adult: High

Tolerance Ranges/Thresholds

Adult: found at <4,500 feet elevation

Site Fidelity

Adult: High

Habitat Narrative

Adult: Habitat requirements are broad. Topminnow prefer shallow, warm, fairly quiet waters in ponds, cienegas, tanks, pools, springs, small streams and the margins of larger streams. Dense mats of algae and debris along the margins of the habitats are an important component for cover and foraging. Substrates of organic muds and detritus also provide foraging areas. Species historically also occurred in backwaters of large rivers but is currently isolated to small streams and springs. Due to surface and groundwater developments that eliminated connectivity between aquatic habitats, topminnow have limited movement potential out of occupied habitats. Topminnows are found below 4,500 feet of elevation. Habitat requirements of topminnows are broad. They prefer shallow, warm, fairly quiet waters. However, they can become acclimated to a much wider range of conditions. Both lentic habitats and lotic habitats with moderate current are easily tolerated. Temperatures from near freezing under ice to 37C have been reported, with a maximum tolerance of 43C for brief periods (Heath 1962). Topminnows can live in a wide range of water chemistries, with recorded values of pH from 6.6 to 8.9, dissolved oxygen readings from 2.2 to 11 milligrams/liter (Meffe et al. 1983), and salinities from very dilute to sea water (Schoenherr 1974). The widespread historic distribution of Gila topminnows throughout rivers, streams, marshes, and springs of the Gila River Basin is evidence for their tolerance of these environmental extremes. One reestablished population, Mud Springs, survived for 16 years in a simple cement watering trough before being moved. Meffe et al. (1983) reported that topminnows can tolerate almost total loss of water by burrowing into the mud for 1-2 days. Preferred habitats contain dense mats of algae and debris, usually along stream margins or below riffles, with sandy substrates sometimes covered with organic muds and debris (Minckley 1973). Topminnows are usually found in the upper 1/3 of the water column and young show a preference for the warmest and shallowest areas (Forrest 1992). Simms and Simms (1992) found topminnows occupying pools, glides, and backwaters more frequently than marshes or areas of fast flow. According to Schoenherr (1974), the spring-heads presently occupied by Gila topminnows are questionable as preferred habitat. Destruction of historically occupied habitats such as the marshes, sloughs, backwaters, and edgewaters of larger rivers and presence of nonnative fishes in such habitats that remain has undoubtedly forced Gila topminnow out of their preferred historic of conditions in these habitats has allowed them to maintain populations with less impact from nonnative fishes.

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Dispersal

Adult: Limited by habitat

Dependency on Other Individuals or Species for Dispersal

Adult: Unknown

Dispersal/Migration Narrative

Adult: Due to surface and groundwater developments that eliminated connectivity between aquatic habitats, topminnow have limited movement potential out of occupied habitats. Topminnow are non-migratory.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

Unknown

Number of Populations:

33 within the U.S.; 51 in Mexico (NatureServe 2015)

Population Size:

Unknown

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Unknown

Adaptability:

Unknown

Population Narrative:

Prior to 1940, the Gila topminnow was considered "one of the commonest fishes in the southern part of the Colorado River basin" (Hubbs and Miller 1941). Subsequently, populations in the U.S. declined dramatically (decline of <30 percent to relatively stable) . Reintroductions have been made, and the subspecies occidentalis is now widely distributed throughout its former range. Since being listed in 1967, this species has been reestablished into more locations than any other fish in the Southwest. However, both naturally occurring and reestablished populations continue to decline.The status of the undescribed subspecies in the upper Rio Mayo, Sonora, is unknown, but is likely secure due to wide and remote range (Minckley et al. 1991). Current status of the reintroduced population in New Mexico is unknown (New Mexico Department of Game and Fish 1996), but the species is stable (A. Villarreal L., pers. comm., 1997) or declining (Weedman 1998) in Sonora. TNHC (1996) mapped one collection location in New Mexico, 32 locations in Arizona, and 51 locations in Mexico. It is thought to been extirpated from New Mexico in the 1950s; since reintroduced at one location, current status is unknown (New Mexico Department of Game and Fish 1996). In Sonora, there are an estimated 101+

extant occurrences with 80 percent in good condition; the species was last surveyed in 1996 (A. Villarreal L., pers. comm., 1997).(NatureServe 2015).

Threats and Stressors

Stressor: Historic and current habitat destruction
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Historic events in the late 1800s and early 1900s caused widespread habitat changes throughout the Southwest, which continue to this day. Heavy overgrazing and wood cutting combined with a drought during 1891-1893 caused extensive loss of vegetation; this resulted in a further 50-75 percent loss from cattle herds (Hastings and Turner 1965; Deacon and Minckley 1974; Hendrickson and Kubly 1984; Bahre and Hutchison 1985); the lack of vegetation made the area vulnerable to erosion when the drought ended; floods, unbuffered by vegetation, scoured watercourses, deeply incised marshy cienega habitats, lowered water tables, desiccated watersheds, and turned permanent flowing waters into occasionally flooded arroyos; marshes dried, springs failed, and streamside backwaters and inlets disappeared (Miller 1961; Fradkin 1981; Rea 1983; Hendrickson and Minckley 1985; Bahre 1991); groundwater pumping caused additional lowering of the water table (Rogers 1980); habitats were further impacted by construction of water diversions and dams, which dewatered downst permanently altered much of the aquatic habitat in the arid southwest. (Minckley et al. 1991). Current and future activities also present a great risk. Land use practices such as livestock grazing, mining, timber cutting, road maintenance, and recreation pose threats through increased erosion, intensified flood events, and decreased groundwater storage to both existing populations and habitats proposed for reestablishment. In addition, continued urban and suburban development and population growth affects potential recovery of the species through increased groundwater pumping and diversions to supply the growing populations, stream and river channelization, and increased water pollution. Some populations are also at risk because they are supported in habitats constructed or modified by man and require periodic maintenance for support of the population. Performance of this maintenance may be limited by future budgetary restrictions within the various agencies responsible for management. In addition, habitats identified for recovery of Gila topminnow do not receive statutory protection and may be damaged or destroyed before Gila topminnow reestablishment, thus continuously reducing the likelihood of recovery of the species.

Stressor: Nonnative species
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Introduction of nonnative pathogens, parasites, plants, invertebrates, amphibians and fish may negatively affect the native fishes of the Southwest. At least one parasitic copepod, Lernaea cyprinacea, has been introduced to Arizona (James 1968) and other parasites and diseases are possible. Introduced plants such as salt cedar (Tamarix ramosissima), and white water cress (Rorippa nasturtium-aquaticum), alter aquatic habitats and displace native vegetation. The Asian clam (Corbicula fluminea) has probably or soon will be introduced into the Santa Cruz River basin via the Central Arizona Project canal, which is likely to affect nutrient cycling and food availability for Gila topminnow. Several species of crayfish have also become

established in Arizona and investigations into their effects on native fishes have only recently begun. The nonnative and predatory bullfrog (Rana catesbiana), is also widespread and abundant throughout Gila topminnow historic range and is known to feed on fishes (Rosen and Schwalbe 1996). These are but a few examples of the variety of nonnative taxa that does or may affect Gila topminnow recovery. Negative impacts to Gila topminnow from nonnative predatory sport fishes such as largemouth bass (Micropterus salmoides) smallmouth bass (Micropterus dolomieu) and green sunfish, (Lepomis cyanellus) is also a problem. Degradation of habitats is a well recognized factor in establishment of nonnative species (Courtenay and Stauffer 1984, Arthington et al. 1990, Soule 1990, Aquatic Nuisance Species Task Force 1994).

Stressor: Mosquito fish
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Introduction of the western mosquitofish has caused the most problems for Gila topminnow. Mosquitofish tolerate similar environmental extremes and occupy similar habitats as Gila topminnow (Meffe et al. 1983). The mechanism of replacement of topminnows by mosquitofish occurs at many levels-- direct predation and competition for space has been observed (Schoenherr 1974). Mosquitofish prey directly on young topminnows and cause the death of adults due to infection following the shredding or removal of fins (Schoenherr 1974; Meffe 1985). Competition for space, resulting in harassment of male and female topminnows by larger, dominant, more aggressive female mosquitofish also seemed instrumental in replacement of Gila topminnow by mosquitofish (Schoenherr 1974).

Recovery

Reclassification Criteria:
Survival of the species in the U.S. is ensured by protecting existing natural populations and maintaining refugia stocks from each;

Populations are reestablished within the species' historic range according to guidelines identified in this plan;

Protocols for population, habitat and genetic monitoring are developed, funded, and started. Natural (Level 1) populations and mixed populations will be established in Level 2 and Level 3 sites as described in the recovery section of this plan. Level 2 populations will be considered established only when they have persisted a minimum of 10 years.

Delisting Criteria:
None.

Recovery Actions:
- Prevent extinction by protecting remaining natural and long-lived reestablished populations.
- Reestablish and protect populations throughout historic range.
- Monitor natural and reestablished populations and their habitats.
- Develop and implement genetic protocol for managing populations.
- Study life-history, genetics, ecology, and habitat of Gila topminnow and interactions with nonnative aquatic species.

- Inform and educate the public and resource managers.
- None developed; see Recovery Action

References

USFWS. 1999. Gila Topminnow (Poeciliopsis occidentalis occidentalis), Draft Revised Recovery Plan, Arizona Game and Fish Department, Phoenix, AZ, for Region 2, U.S. Fish and Wildlife Service, Albuquerque, NM, December 1988. 89 p.

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USFWS. 1999. Gila Topminnow (Poeciliopsis occidentalis occidentalis), Draft Revised Recovery Plan, Arizona Game and Fish Department, Phoenix, AZ, for Region 2, U.S. Fish and Wildlife Service, Albuquerque, NM, December 1988. 89 p

SPECIES ACCOUNT: *Ptychocheilus lucius* (Colorado pikeminnow (=squawfish))

Species Taxonomic and Listing Information

Listing Status: Endangered/Experimental Population, Non-Essential; 03/11/1967, 07/24/1985; Mountain-Prairie Region (R6) (USFWS, 2016)

Physical Description

The Colorado pikeminnow is a long, slender, cylindrical fish with silvery sides, greenish back, and creamy-white belly. The tail trunk is thick with a triangular black patch at the base of the caudal fin. The head is large with a terminal mouth and thickened lips and jaws that lack teeth, and a maxillary (upper jaw) that extends past the middle of the eye. Large adults are silverywhite throughout and salmon-like in appearance. Spawning adults in June–August are tinged with light rosy-red on the head and body, with pimple-like tubercles on the head and paired fins. Dorsal and anal fins typically have 9 principal rays each. Scales are small, cycloid, and silvery with 83–87 along the lateral line. Teeth of the pharyngeal arch are spaced apart and barely hooked in a typical pattern of 2,5-4,2 (Girard 1856).

Taxonomy

The Colorado pikeminnow (Ptychocheilus lucius) is the largest cyprinid (minnow) fish endemic to the Colorado River Basin (Tyus 1991). The species is a member of a unique assemblage of fishes native to the Colorado River Basin, consisting of 35 species with 74 percent level of endemism (Miller 1959). It is one of four mainstem, big-river fishes currently listed as endangered under the ESA; others are the humpback chub (Gila cypha), bonytail (Gila elegans), and razorback sucker (Xyrauchen texanus).

Historical Range

The species was first reported in the upper basin in 1825 by Colonel William H. Ashley (Morgan 1964), and it was common to abundant in the Green and upper Colorado rivers and their tributaries (Banks 1964; Vanicek 1967; Holden and Stalnaker 1975; Seethaler 1978). It was found from Rifle, Colorado, downstream in the mainstem upper Colorado River (Beckman 1963); from Delta, Colorado, downstream on the Gunnison River (Burdick 1995); and from Paradox Valley downstream on the Dolores River (Lynch et al. 1950). In the Green River, it was reported as far upstream as Green River, Wyoming (Ellis 1914; Baxter and Simon 1970); from Craig, Colorado, downstream on the Yampa River; from Rangely, Colorado, downstream and in the White, lower Price, and Duchesne rivers (Tyus and Haines 1991; Cavalli 1999; Muth et al. 2000).

Current Range

Three wild populations of Colorado pikeminnow are found only in the upper basin, and the species currently occupies only about 25% of its historic range basin-wide. These wild populations of Colorado pikeminnow are found in about 1,753 km of riverine habitat in the Green River, upper Colorado River, and San Juan River subbasins. Occupied habitat occurs in the Green River from Lodore Canyon to the confluence of the Colorado River (Tyus 1991; Bestgen and Crist 2000); the Yampa River downstream of Craig, Colorado (Tyus and Haines 1991); the Little Snake River from its confluence with the Yampa River upstream into Wyoming (Marsh et al. 1991; Wick et al. 1991); the White River downstream of Taylor Draw Dam and Kenney

Reservoir (Tyus and Haines 1991); the lower 143 km of the Price River (Cavalli 1999); the lower Duchesne River; the upper Colorado River from Palisade, Colorado, to Lake Powell (Valdez et al. 1982a; Osmundson et al. 1997, 1998); the lower 54 km of the Gunnison River (Valdez et al. 1982b; Burdick 1995); the lower 2 km of the Dolores River (Valdez et al. 1992); and 241 km of the San Juan River downstream from Shiprock, New Mexico, to the Lake Powell inflow (Jordan 1891; Koster 1960; Olson 1962; Holden 1999; Propst 1999). Natural reproduction of Colorado pikeminnow is currently known from the Green, Yampa, upper Colorado, Gunnison, and San Juan rivers.

Distinct Population Segments Defined

No.

Critical Habitat Designated

Yes; 3/21/1994.

Legal Description

On March 21, 1994, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Ptychocheilus lucius (Colorado squawfish) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes six critical habitat units (CHUs) in Colorado, New Mexico and Utah (59 FR 13374-13400).

The critical habitat designation for Ptychocheilus lucius includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Ptychocheilus lucius.

Critical Habitat Designation

The critical habitat designation for Ptychocheilus lucius includes six CHUs in Delta, Mesa, Garfield, Moffat and Rio Blanco Counties, Colorado; Uintah, Carbon, Garfield, Grand, Emery, Wayne and San Juan Counties, Utah; and San Juan County, New Mexico (59 FR 13374-13400).

Unit 1—Colorado: Moffat County. The Yampa River and its 100-year flood plain from the State Highway 394 bridge in T.6N., R.91W., sec. 1 (6th Principal Meridian) to the confluence with the Green River inT.7N., R.103W., sec. 28 (6th Principal Meridian).

Unit 2—Utah: Uintah, Carbon, Grand, Emery, Wayne, and San Juan Counties; and Colorado: Moffat County. The Green River and its 100-year flood plain from the confluence with the Yampa River in T.7N., R.103W., sec. 28 (6th Principal Meridian) to the confluence with the Colorado River in T.30S., R19E., sec. 7 (Salt Lake Meridian).

Unit 3—Colorado: Rio Blanco County; and Utah: Uintah County. The White River and its 100-year flood plain from Rio Blanco Lake Dam in T.1N., R.96W., sec. 6 (6th Principal Meridian) to the confluence with the Green River in T.9S., R.20E., sec. 4 (Salt Lake Meridian).

Unit 4—Colorado: Delta and Mesa Counties. The Gunnison River and its 100-year flood plain from the confluence with the Uncompahgre River in T.15S., R.96W., sec. 11 (6th Principal Meridian) to the confluence with the Colorado River in T.1S., R.IW., sec. 22 (Ute Meridian).

Unit 5—Colorado: Mesa and Garfield Counties; and Utah: Grand, San Juan, Wayne, and Garfield Counties. The Colorado River and its 100-year flood plain from the Colorado River Bridge at exit 90 north off Interstate 70 inT.6S., R.93W., sec. 16 (6th Principal Meridian) to North Wash including the Dirty Devil arm of Lake Powell up to the full pool elevation in T.33S., R.14E., sec. 29 (Salt Lake Meridian).

Unit 6—New Mexico: San Juan County; and Utah: San Juan County. The San Juan River and its 100-year flood plain from the State Route 371 Bridge inT.29N., R.13W., sec. 17 (New Mexico Meridian) to Neskahai Canyon in the San Juan arm of Lake Powell in T.41S., R.IIE., sec. 26 (Salt Lake Meridian) up to the full pool elevation.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Ptychocheilus lucius critical habitat consists of three components (59 FR 13374-13400):

(1) Water: This includes a quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species.

(2) Physical Habitat: This includes areas of the Colorado River system that are inhabited or potentially habitable by fish for use in spawning, nursery, feeding, and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100- year flood plain, which when inundated provide spawning, nursery, feeding and rearing habitats, or access to these habitats.

(3) Biological Environment: Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although considered normal components of this environment, are out of balance due to introduced nonnative fish species in many areas.

Life History

Feeding Narrative

Larvae: Cladocerans, copepods, and midge larvae are the principal food items of young up to 50 mm TL in nursery backwaters (Vanicek 1967; Jacobi and Jacobi 1982; Muth and Snyder 1995). Young in hatchery troughs may become cannibalistic at sizes of less than 50 mm TL (personal communication, F. Pfeifer, U.S. Fish and Wildlife Service).

Juvenile: Insects became important for fish up to 100 mm TL, after which fish are the main food item.

Adult: Adult Colorado pikeminnow are generally considered piscivores and the main native predator of the Colorado River Basin because of their large size and large mouth (Vanicek and Kramer 1969; Minckley 1973; Holden and Wick 1982). As a member of the cyprinid family, Colorado pikeminnow lack jaw, vomerine, or palatine teeth, but possess instead large pharyngeal teeth, located on the first modified gill arch at the base of the throat. Adults consume primarily softrayed fishes, including bluehead sucker (Catostomus discobolus), flannelmouth sucker (C. latipinnis), red shiner, sand shiner, and fathead minnow (Osmundson 1999). Colorado pikeminnow have also been reported with channel catfish lodged in their throat, possibly leading to death of the fish (McAda 1980; Pimental et al. 1985). Colorado pikeminnow have been caught by anglers using various baits, including Mormon crickets (Anabrus migratorius; Tyus and Minckley 1988), carcasses of mice, birds, and rabbits (Beckman 1963), as well as artificial lures and spoons (Quartarone 1995)

Reproduction Narrative

Larvae: Newly hatched larvae are 6.0–7.5 mm long (Hamman 1981), which emerge from spawning cobbles 3–15 days after hatching and drift predominantly as protolarvae (Haynes et al. 1984; Nesler et al. 1988). Larvae hatched in the lower Yampa River may drift 50–120 miles downstream to nursery backwaters. High to moderate spring flows rework sediment deposits (cobbles and gravel), which seems to increase larval survival and results in a strong year class (Van Steeter and Pitlick 1998; Osmundson 1999).

Adult: The Colorado pikeminnow is a long-lived fish that evolved in a variable system, with high adaptability to natural environmental variability and resilience to natural catastrophes. This evolution has become manifest as pulsed recruitment from periodic strong year classes, great longevity of adults, and low vulnerability of adults to environmental influences. Great longevity and stability of adults provides a “storage effect” for populations, into which periodic recruitment from strong year classes allows fish to become stored (Gilpin 1993). This is seen as a way that Colorado pikeminnow maintain long-term population viability and stability under environmental variation. A critical aspect of recovery is increased frequency of strong year classes. Strong year classes of Colorado pikeminnow have been linked to years immediately following wet hydrologic conditions resulting in high spring-runoff flows (McAda and Ryel 1999; Valdez et al. 1999). High to moderate spring flows rework sediment deposits, which seems to increase larval survival and results in a strong year class (Van Steeter and Pitlick 1998; Osmundson 1999). Characteristically, two or three strong year classes occur in consecutive years, with a recurrence interval of 7–10 years. Shortening this recurrence interval by increasing the frequency of high spring flows increases the likelihood of greater recruitment, population expansion, and long-term stability. Mid-summer, rain-induced flow spikes have been linked to spawning cues (Nesler et al. 1988) and may stimulate reproduction and add to the success of strong year classes. Spawning activity begins after spring runoff at water temperatures typically between 16 and 23°C . Colorado pikeminnow are broadcast spawners that scatter adhesive eggs over cobble substrate which incubate in interstitial spaces. Hatching success is greatest at 20–24°C with incubation time of 90–121 h (Hamman 1981; Marsh 1985). Newly hatched larvae are 6.0–7.5 mm long (Hamman 1981), which emerge from spawning cobbles 3–15 days after hatching and drift predominantly as protolarvae (Haynes et al. 1984; Nesler et al. 1988). Larvae hatched in the lower Yampa River may drift 50–120 miles downstream to nursery backwaters.

Geographic or Habitat Restraints or Barriers

Adult: Dams, nonnative predatory fishes

Spatial Arrangements of the Population

Adult: Metapopulations

Tolerance Ranges/Thresholds

Adult: prefer temperatures between 16 and 23°C for reproduction;

Site Fidelity

Adult: High; returns to spawing site

Habitat Narrative

Larvae: After hatching and emerging from the spawning substrate, Colorado pikeminnow larvae drift downstream to backwaters in sandy, alluvial regions, where they remain through most of their first year of life (Holden 1977; Tyus and Haines 1991; Muth and Snyder 1995).These sheltered nursery backwaters are restructured by high spring flows and maintained by relatively stable base flows. High to moderate spring flows rework sediment deposits, which seems to increase larval survival and results in a strong year class (Van Steeter and Pitlick 1998; Osmundson 1999).

Juvenile: See adult.

Adult: Colorado pikeminnow live in warm-water reaches of the Colorado River mainstem and larger tributaries, and require uninterrupted stream passage for spawning migrations and dispersal of young. The species is adapted to a hydrologic cycle characterized by large spring peaks of snowmelt runoff and low, relatively stable base flows. High spring flows create and maintain inchannel habitats, and reconnect floodplain and riverine habitats, a phenomenon described as the spring flood-pulse (Junk et al. 1989; Johnson et al. 1995). Throughout most of the year, juvenile, subadult, and adult Colorado pikeminnow utilize relatively deep, low-velocity eddies, pools, and runs that occur in nearshore areas of main river channels (Tyus and McAda 1984; Valdez and Masslich 1989; Tyus 1990, 1991; Osmundson et al. 1995). In spring, however, Colorado pikeminnow adults utilize floodplain habitats, flooded tributary mouths, flooded side canyons, and eddies that are available only during high flows (Tyus 1990, 1991; Osmundson et al. 1995). High spring flows maintain channel and habitat diversity, flush sediments from spawning areas, rejuvenate food production, form gravel and cobble deposits used for spawning, and rejuvenate backwater nursery habitats (McAda 2000; Muth et al. 2000). Cobble and gravel deposits used for spawning are formed at high flows. Increased production and recruitment have been correlated with moderate-to-high water years (Converse et al. 1999; McAda and Ryel 1999; Valdez et al. 1999). Such environments may be particularly beneficial for Colorado pikeminnow because other riverine fishes gather in floodplain habitats to exploit food and temperature resources, and may serve as prey. Such low-velocity environments also may serve as resting areas for Colorado pikeminnow. River reaches of high habitat complexity appear to be preferred. Larvae typically drift downstream from spawning areas to broad alluvial reaches where they occupy sheltered nursery backwaters, restructured by high spring flows and maintained by relatively stable base flows. High spring flows also disadvantage nonnative fishes (McAda and Kaeding 1989; Valdez 1990; Hoffnagle et al. 1999), reducing predation and competition. Low base flows also increase shoreline food production.

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Larvae: Non-migratory

Juvenile: Non-migratory

Adult: Yes; long-distance

Dispersal

Larvae: Drift downstream to nursery backwaters

Juvenile: 2–4 years of life, then move upstream to recruit to adult populations and establish home ranges

Dispersal/Migration Narrative

Larvae: After hatching and emerging from spawning substrate, larvae drift downstream to nursery backwaters that are restructured by high spring flows and maintained by relatively stable base flows.

Juvenile: Young Colorado pikeminnow remain near nursery areas for the first 2–4 years of life, then move upstream to recruit to adult populations and establish home ranges (Osmundson et al. 1998). In the upper Colorado River, distance moved was inversely related to fish size; displacement of fish < 550 mm TL averaged 33.6 km and displacement for fish less than or equal to 550 mm TL was only 7.5 km (Osmundson et al. 1998). Similar average movement of 31.8 km was observed for 43 radiotagged adults during fall and spring in the Green River (Archer et al. 1985). It has been hypothesized (Gilpin 1993) that upstream return by subadults provides connectivity and gene flow between the Green and upper Colorado rivers, resulting in an exchange of genes.

Adult: The Colorado pikeminnow is a long-distance migrator; moving hundreds of kilometers to and from four major spawning areas. It has been hypothesized (Gilpin 1993) that upstream return by subadults provides connectivity and gene flow between the Green and upper Colorado rivers, resulting in a panmictic population for the entire upper basin with evidence of source/sink dynamics. It has been hypothesized (Gilpin 1993) that upstream return by subadults provides connectivity and gene flow between the Green and upper Colorado rivers, resulting in an exchange of genes between these two populations. Adult Colorado pikeminnow remain in home ranges during fall, winter, and spring and may move considerable distances to and from spawning areas in summer. Individuals move to spawning areas shortly after runoff in early summer, and return to home ranges in August and September (Tyus 1990; Irving and Modde 2000). Round-trip movements of up to 950 km have been reported (Irving and Modde 2000), with some fish “straying” between rivers within the Green River subbasin(Tyus 1985, 1990; Tyus and McAda 1984). Adults may return in consecutive years to overwinter in the same areas (Wick et al. 1981; Valdez and Masslich 1989).

Population Information and Trends

Number of Populations:

3 metapopulations

Population Size:

6,600 to 8,900 wild adults

Minimum Viable Population Size:

2,600

Resistance to Disease:

Not recorded, but appear to be high.

Population Narrative:

Colorado pikeminnow in the Upper Colorado River Basin are distributed in three geographically separate subbasins, where the migratory nature of the species and documented mixing of stocks indicate that Colorado pikeminnow function as a metapopulation. Recent preliminary estimates of abundance summed for the three Colorado pikeminnow populations range from about 6,600 to 8,900 wild adults. The precision and reliability of these estimates vary, and approximate numbers are provided as a general indication of the size of populations in the basin. Estimates of subadults are not currently available for all populations, and precise estimates of adults and subadults will be developed in order to determine if demographic criteria are met for downlisting and delisting. Estimates of adults for the three subbasins are: Green River, 6,000–8,000 (Nesler 2000; personal communication, K. Bestgen, Colorado State University); upper Colorado River, 600–900 (Nesler 2000; Osmundson 2002 [includes some subadults]); and San Juan River, 19–50 (Holden 1999; personal communication, D. Ryden, U.S. Fish and Wildlife Service). Two principal spawning sites have been identified in the Green River subbasin (Tyus 1990). Crowl and Bouwes (1998) estimated that 1,000 adults were associated with the spawning site near Three Fords Canyon in Gray Canyon of the lower Green River, and 1,400 adults were associated with the spawning site in the lower 32 km of the Yampa River.

Threats and Stressors

Stressor: Streamflow regulation
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Streamflow regulation and associated habitat modification are identified as primary threats to Colorado pikeminnow populations. Regulation of streamflows in the Colorado River Basin is manifested as reservoir inundation of riverine habitats and changes in flow patterns, sediment loads, and water temperatures. The effect of flow modifications on Colorado pikeminnow includes reduction in high-velocity flows that flush sediments from spawning cobbles (Van Steeter and Pitlick 1998), reduced channel and habitat complexity and concomitant losses in food production (Osmundson 1999), reduced availability and quality of backwater nursery habitats (Tyus and Karp 1989), and loss of flooded bottomlands during spring runoff as feeding areas and as thermal refugia for maturation of gonads (Tyus 1990).

Stressor: Habitat modification
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Starting with Hoover Dam in 1935, numerous dams were constructed that fragmented and inundated riverine habitat; released cold, clear waters; altered ecological processes; affected seasonal availability of habitat; and blocked fish passage. Reservoirs formed by these dams were stocked with a variety of nonnative fishes for recreational fisheries, and these fishes preyed upon

and competed with the native fishes. Total Colorado pikeminnow habitat lost to reservoir inundation in the upper basin is about 700 km. Cold-water releases have eliminated most native fishes from river reaches immediately downstream of dams. River temperatures have been modified from seasonal lows of near freezing and highs of nearly 30°C to relatively constant dam releases of about 4–13°C. These cold releases have caused reproductive failure and slowed growth of the warm-water native fishes. Adult Colorado pikeminnow are long distance migrators to and from spawning sites (Tyus 1990), and historically, the only physical barriers to movement were natural rapids and swift turbulent flows, which were probably only seasonal impediments to fish movement. The numerous human-made dams have fragmented Colorado pikeminnow habitat and blocking migration corridors.Ten barriers are identified in the upper basin upstream of Glen Canyon Dam within occupied habitat of Colorado pikeminnow.

Stressor: Nonnative fish species
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Nonnative fish species in backwaters and other low-velocity shoreline habitats in alluvial reaches of the upper Colorado, Green, and San Juan riversthat are important nursery areas for larval and juvenile Colorado pikeminnow habitats limit the success of Colorado pikeminnow recruitment. Predation by black bullhead (Ameiurus melas), green sunfish (Lepomis cyanellus), largemouth bass (Micropterus salmoides), and black crappie (Pomoxis nigromaculatus) are a significant mortality factor of young-of-year and yearling Colorado pikeminnow stocked in riverside ponds along the upper Colorado River. Adult red shiner (Cyprinella lutrensis) are known predators of larval native fish in backwaters of the upper basin (Ruppert et al. 1993), and predation by nonnative fishes such as red shiner may influence within-year-class recruitment of Colorado pikeminnow (Bestgen et al. 1997). Channel catfish (Ictalurus punctatus) and northern pike (Esox lucius) have been identified as the principal nonnative threats to subadult and adult Colorado pikeminnow in the upper basin. Adult Colorado pikeminnow apparently use the same habitats as adult channel catfish and northern pike suggesting the potential for negative interactions, especially during periods of limited resource availability (Wick et al. 1985; Tyus and Karp 1989; Tyus and Beard 1990; Nesler 1995).

Stressor: Pesticides and pollutants
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Hazardous-materials spills are identified as a threat to Colorado pikeminnow. Although the States of Colorado, Utah, and New Mexico, where the species occurs, have state-wide hazardous materials plans, these may not be adequate to provide protection against spills into the river.The need for conservation plans and agreements to provide reasonable assurances that recovered Colorado pikeminnow populations will be maintained are needed to ensure long-term management and protection of the species, and should include (but not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats. Another cause of degraded water quality is the Atlas Mills tailings pile located on the north bank of the Colorado River near Moab, Utah. There are two significant threats to endangered fish posed by the Atlas Mills tailings pile. The first is from toxic discharges of pollutants, particularly ammonia, through groundwater to the Colorado

River. The second is the risk of catastrophic pile failure, that could bury important nursery areas and destroy other fish habitat. Selenium is hypothesized as contributing to the decline of the endangered fishes of the Colorado River Basin. It is a water-quality factor that may inhibit recovery by adversely affecting reproduction and recruitment (Hamilton and Wiedmeyer 1990; Stephens et al. 1992; Hamilton and Waddell 1994; Hamilton et al. 1996; Stephens and Waddell 1998; Osmundson et al. 2000a). Selenium concentrations in certain areas of the basin exceed those shown to impact fish and wildlife elsewhere, and, although results are inconclusive as to exposure thresholds that cause specific effects, some studies suggest deleterious effects on Colorado pikeminnow and razorback sucker.

Recovery

Reclassification Criteria:
Criterion 1 for Downlisting: The overall trends in wild and stocked adult abundances are stable or increasing over a continuous 15-year period in the Green, upper Colorado, and San Juan River subbasins. Adult abundances will be measured using standardized estimation techniques (USFWS, 2023).

Adult abundance thresholds are met over a consecutive 10-year period, as described in Table 1 for down- and de-listing (USFWS, 2023).

Criterion 3 for Downlisting: Wild recruitment to sexual maturity equals or exceeds annual adult mortality over a continuous 10-year period in the Green, upper Colorado, and San Juan River basins (USFWS, 2023).

Recovery Criteria 4 – Reproductive Success Mean density of wild age-0 juveniles collected in autumn standardized sampling meets thresholds described in Table 2 over a continuous 10-year period in the Green, upper Colorado, and San Juan River basins (USFWS, 2023).

Recovery Priority Number: 8C

Delisting Criteria:
Criterion 1 for Delisting: The overall trends in wild adult abundances are stable or increasing over a continuous 15-year period in the Green, upper Colorado, and San Juan River subbasins. Adult abundances will be measured using standardized estimation techniques (USFWS, 2023).

Adult abundance thresholds are met over a consecutive 10-year period, as described in Table 1 for down- and de-listing (USFWS, 2023).

Criterion 3 for Delisting: Wild recruitment to sexual maturity equals or exceeds annual adult mortality over a continuous 15-year period in the Green, upper Colorado River, and San Juan River basins (USFWS, 2023).

Recovery Criteria 4 – Reproductive Success Mean density of wild age-0 juveniles collected in autumn standardized sampling meets thresholds described in Table 2 over a continuous 10-year period in the Green, upper Colorado, and San Juan River basins (USFWS, 2023).

Recovery Criterion 5 – Threats-based (Delisting) Regulatory mechanisms or conservation plans are in place that include stakeholder commitments to management actions that support Colorado pikeminnow populations beyond delisting in the Colorado, Green, and San Juan subbasins. Commitments should include management actions such as controlling nonnative fishes, operating fish passages and entrainment reduction facilities, and maintaining a genetic refuge. Plans or management actions should be revised and updated based on the best available science (USFWS, 2023).

Recovery Actions:

- Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.
- Provide passage over barriers within occupied habitat to allow adequate movement and, potentially, range expansion.
- Investigate options for providing appropriate water temperatures in the Gunnison River.
- Minimize entrainment of subadults and adults in diversion canals.
- Ensure adequate protection from overutilization.
- Ensure adequate protection from diseases and parasites.
- Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.
- Control problematic nonnative fishes as needed.
- Minimize the risk of hazardous-materials spills in critical habitat.
- Remediate water-quality problems.
- Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).
- Priority 1 Actions 1. Manage river flows in all subbasins to include both inter- and intra-annual variability that approximates the natural hydrograph and supports Colorado pikeminnow life history. This action provides an ecologically based suite of flows throughout the year and between years. For example, spring peak flows should clean spawning substrates, maintain channel complexity, create nursery habitats, provide access to floodplains, and promote movements to spawning areas. Base flows should support fish movement, maintain food web productivity, transport larvae, and maintain nursery habitats. 2. Operate and maintain fish passage facilities in all subbasins to facilitate Colorado pikeminnow movement. This action provides habitat access across the species' current range that allows for use suitable to fulfill life history requirements. 3. Control nonnative fish populations that reduce Colorado pikeminnow abundance and survival, particularly in the Colorado and Green River subbasins. This action improves Colorado pikeminnow recruitment and survival by reducing predation and competition from problematic nonnative species. Successful implementation of this action will minimally involve determining the level of invasive species reductions needed to improve Colorado pikeminnow demographics, developing new strategies and methods, and implementing additional or novel methods to suppress or eradicate nonnative fishes at a landscape scale. 4. Develop captive broodstock(s) from wild fish to maintain existing genetic diversity of populations in the Colorado and Green River subbasins. This action protects the extant genetic and life history lineages. Broodstock(s) should serve as a genetic refuge and provide offspring for augmentation programs where needed. If determined necessary to meet demographic recovery criteria, this action should include production, rearing, and stocking

sufficient numbers of Colorado pikeminnow to meet stocking goals and augmentation plans (USFWS, 2023).

- Priority 2 Actions 5. Conserve, or improve, native fish communities to provide a forage base for all life stages of Colorado pikeminnow in all subbasins. This action supports growth and survival of Colorado pikeminnow. Supporting native fish communities may include controlling nonnative fish to reduce impacts to native fish species and augmenting or reintroducing native fish species where necessary, in addition to implementing flow management described for Colorado pikeminnow. 6. Create and maintain habitats for Colorado pikeminnow using mechanical restoration methods or flow management actions in all subbasins. This action provides necessary habitats through a variety of mechanisms, including if climate change causes natural hydrologic conditions to become insufficient to perform habitat maintenance functions. Flow management activities under this action might differ from those intended to directly benefit Colorado pikeminnow populations, such as flows to reverse negative effects of vegetative encroachment or to transport sediment. 7. Develop partnerships to improve land management practices that may reduce water quality via runoff of contaminants or spills in all subbasins. This action protects stream water quality. 8. Operate dams to provide appropriate release water temperatures to meet life history requirements, specifically from Flaming Gorge Dam, Navajo Dam, and the Aspinall Unit. This action should be continued at Flaming Gorge Dam or enacted where feasible at the other locations if water temperatures are a limitation in achieving demographic recovery criteria. 9. Expand Colorado pikeminnow access into the greatest feasible extent of historically occupied range. This action increases the species' resiliency, redundancy, and representation, recognizing that Colorado pikeminnow is currently limited to a small portion of its former range. Implementation of this action might include exploring opportunities to reintroduce the species, constructing additional passage or improvement projects, or modifying existing structures where access is a limitation to achieving demographic recovery criteria. Warmer stream temperatures from climate change and future management actions could lead to improved habitats outside the current distribution for Colorado pikeminnow. Periodic assessments should be conducted to determine the suitability of additional reaches to contribute to recovery of the species, particularly in the LCRB. 10. Prevent escapement of invasive fishes from source populations by constructing exclusion facilities, replacing invasive species in reservoirs with compatible sport fisheries, and eliminating sources where possible. This action reduces threats posed by the expansion of nonnative species into current range of Colorado pikeminnow. 11. Reduce illicit and unintentional movements of all invasive taxa that could become established in Colorado pikeminnow current range by conducting outreach, enacting regulations where needed, and enforcing regulations. This action reduces the risks posed by the introduction or establishment of additional invasive species (USFWS, 2023).

Conservation Measures and Best Management Practices:

- Empirical evidence and modeling has shown that large-scale nonnative fish removal can result in population level reductions in abundance and biomass of the targeted nonnative species. However, eradication of problematic nonnative fish species is difficult and control of their populations will likely be a long-term management action (Martinez et al. 2014). The effects of nonnative fish removal are often short lived as removal rates may not be sufficient to result in either a population or reproductive crash, where reproduction is insufficient to offset removal and natural mortality (Figure 37 and Figure 39; Breton et al. 2014; Zelasko et al. 2015; Pennock et al. 2018). Without such a crash, immigration of nonnative fishes among river reaches results in a short-term reduction in population sizes even when large portions of a population are removed. Direct relationships between various nonnative piscivore predation rates and Colorado pikeminnow population dynamics are currently unknown (Miller, P. S. 2018). However, modeling the effect of removal efforts on the target nonnative species can serve to set removal targets and refine management (Figure 39; Breton et al. 2015; Pennock et al. 2018). Until the direct relationships between nonnative species removal and apparent Colorado pikeminnow survival is quantified, considerable uncertainty remains in regards to the amount of effort required to increase Colorado pikeminnow survival to rates that result in population recovery (Bestgen et al. 2007; Miller, P. S. 2018). (USFWS, 2020)

- To describe population stability for each extant population of Colorado pikeminnow, we summarized the trajectory of wild-recruited adults for each population over the most recent seven years of data. A population considered in high condition was one where the intrinsic rate of population growth (lambda) is equal to or greater than 1 for seven years of available data, or where a population is self-sustaining without stocking and recruitment is occurring across many generations. Such a population would be increasing or stable. A population in medium condition was one where the lambda for wild adults equals 1, or the population consists of a small number of wild adults and is increasing, but it requires stocking to supplement adult abundance. A low condition population was one where lambda is less than one, or a wild population that is declining, natural recruitment is not occurring at a level to offset adult mortality, or stocking is required regularly. An extirpated population was one where no wild adults have been documented in the seven most recent estimates. (USFWS, 2020)
- Assessing the abundance of age-0 fish characterizes a Colorado pikeminnow population's resiliency in multiple ways. Age-0 fish abundance can be used to assess adult female fecundity which is an important determinant of long-term population health (Bestgen and Hill 2016a; Miller, P. S. 2018). The abundance of this age class also provides insight into the frequency of optimal river flows (Bestgen and Hill 2016a) and is positively related to the next year's abundance of age-1 fish. Bestgen and Hill (2016a) recommended an annual production of age-0 Colorado pikeminnow for the lower (≥15/100 m2) and middle (≥5/100 m2) Green River, which represent above average densities for the long term data set. The rationale is that higher densities are required to offset declines in both age-0 recruitment and adult abundances. The mean of these values is 10/100 m2 . The long term mean for age-0 catch rates in the upper Colorado River subbasin has been 6.6 fish/100 m2 (McAbee 2017a). A recent analysis for the San Juan River subbasin estimated that catch rates of 6 fish/100 m2 might be expected for an adult population that exceeded the Recovery Goal of 800 adults (Zeigler et al. 2019). We assessed the health of each Colorado pikeminnow analysis unit based on whether the mean age-0 catch rate equaled or exceeded the long term mean (high), was 50-100% of the long term mean (moderate), or was <50% (low) over a seven year period of available data. Lack of detection of age-0 fish over seven years was considered a condition of extirpation. (USFWS, 2020)
- For this SSA, we assessed the proportion of recruits (fish 400-449 mm [16-18 in] TL) relative to the adult population, and whether this proportion is sufficient to offset adult mortality over the most recent seven years where data are available. Once calculated, we partitioned this metric into whether recruit abundances, in relation to the adult abundances, were higher, equal to, or less than mean annual adult mortality over the time period and then assessed current population health (Table 24). Lack of detection of any recruit-sized fish in the last seven years of available data was considered a condition of extirpation. (USFWS, 2020)
- In the upper Colorado River subbasin, age-0 densities have been variable over the long term, and a "spawning spike" was observed in 2015, when large numbers of age-0 Colorado pikeminnow were encountered (Figure 53; Table 22; Miller, P. S. 2018; Breen and Michaud 2018). Catch rates were consistently higher between 1986 and 2000, followed by generally lower densities of fish in the 2000s. Since 2009, higher catch rates of age-0 Colorado pikeminnow in the lower Colorado River

have been inconsistent. The 2015 fish density is not shown in Figure 53 because of the unprecedented catch rate in that year, which was an order of magnitude higher than any other year observed in the project. Table 22 shows the seven year mean for age-0 catch rates including the 2015 spawning spike, as well as the mean with this data excluded. Both values were considered in assessing this factor for the upper Colorado River subbasin in order to capture the uncertainty in this single datum and based on input from investigators in this reach. Data from both the Green and upper Colorado river subbasins suggest spawning occurs regularly in each system, and some level of recruitment has been observed in most years. There is some concern, however, that recent declines in age-0 densities in the Green River may signal that recruitment is not sufficient to offset observed declines in adults (Bestgen and Hill 2016a; Bestgen et al. 2018). (USFWS, 2020)

- For the mid-level "spawning spike" model, adult abundances in the upper Colorado River subbasin would be approximately 40% lower than the most recent three year estimates with a declining growth rate according to the dual-phase model (Figure 67). Other dual-phase models using various magnitudes of spawning spikes produce different trajectories, illustrating the importance of this phenomenon. Models that did not include spawning spikes resulted in adult abundances of less than 100 to around 300 individuals after forty years. Three of the five singlephase models project the adult population for the upper Colorado River subbasin to remain essentially stable over time. In summary, six of ten models indicated the upper Colorado River subbasin population would decline, and this population was only projected to remain stable if spawning spikes continued. Due to stocking, the adult abundance in the San Juan River would remain at current levels over the next 40 years. Although the abundance of adults in two of three populations would decline, we predicted reproduction under this scenario would continue at current frequency (annually) for each population. Considering the adult abundance in the Green River subbasin would significantly decline, we would expect this to be the result of low recruitment. This would likely be the result of decreases in age-0 abundance as has been observed in recent years. Similarly, we predicted a reduction in abundance of age-0 fish in the upper Colorado River subbasin because although spawning spikes might occur, the average abundance of age-0 would decrease and produce the predicted declines in adult numbers. Age-0 abundance in the San Juan River subbasin would also continue to be low rather than undetectable. Since adult abundance would be similar between current conditions and this Status Quo scenario for the San Juan river subbasin, we expect the abundance of stocked recruits to remain the same over a 40-year period. Declines in the majority of adult projections for the Green and upper Colorado river subbasins suggest recruit abundances in those reaches would not be sufficient to offset adult mortalities. Under the Status Quo scenario, we predict that population augmentation would be required to maintain all three analysis units, so some demographic parameters would be the result of stocking and not wild-produced fish. Overall, the three extant analysis units would be in a low resiliency condition within 40 years given the Status Quo future scenario. (USFWS, 2020)
- The SSA summarizes the following resources which were considered to most influence species viability: 1. Variable flow regimes, specifically peak flows to maintain channel complexity and spawning habitats 2. Base flows to provide suitable nursery habitats 3. Suitable water temperatures for spawning and growth 4. Complex, redundant riverine habitats that provide a combination of the necessary elements of spawning, nursery, and foraging areas 5. Abundant, suitable forage base 6. Population size and demographic rates 7. Multiple naturally recruiting and resilient populations 8. Genetic and behavioral diversity (USFWS, 2020)
- RECOMMENDATIONS FOR FUTURE ACTIONS: • Revise the recovery plan, beginning in late 2020 • Update Species Status Assessment report, as needed • Secure wild Colorado pikeminnow from the Green and Colorado rivers for broodstock development in order to improve hatchery representation and to serve as a refuge population should wild populations decline further • Investigate potential

conservation actions that might be implemented in the lower basin (USFWS, 2020a)

- The demographic criteria for downlisting outlined in the recovery goals have not been met in the most recent 5-year period, and populations in the Green and Colorado rivers have declined since the last review. The Green River subbasin population has declined since 2000, and consists of fewer than 1,000 individuals. Recruitment of age-6 fish has not been sufficient to offset adult mortality. The upper Colorado River subbasin population has not exceeded 700 adults since 2008 and has declined since that estimate. Recruitment has been variable annually and estimated to approximate adult mortality over several sampling periods, however, a declining adult population suggests it has not been sufficient to offset mortality in the long term. Despite estimates that suggest the San Juan River basin population has been increasing, abundances over a five year period do not indicate that population has met recovery criteria. (USFWS, 2020a)
- The SSA considered these stressors and also considered several additional stressors that affect the resiliency of extant Colorado pikeminnow populations. All stressors were evaluated in an analysis of rangewide threats, and were evaluated cumulatively (Service 2020, pp. 81 — 126). Additional current and future rangewide threats to Colorado pikeminnow considered in the SSA include a loss of channel complexity as a result of reduced peak flows and channelization (Factor A), entrainment into water delivery systems (Factor E), and potential climate change effects to water supplies (Factors A and E). The SSA also considered existence of two Recovery Programs that coordinate conservation activities in the upper basin; of particular importance is the protection and management of riverine flows to support the species, which are regulated under Records-of-Decisions and other legal frameworks (Factor D). Currently, Colorado pikeminnow is not used for scientific or commercial purposes (Factor B), so neither the 2002 recovery goals nor the SSA considered this as a species stressor. Despite being a threat listed in the 2002 recovery goals, pesticides and pollutants were not addressed in detail in the SSA. Instead, contaminants such as mercury and selenium were reviewed, but the relationship between these contaminants and population dynamics is not clear for subbasins outside of the San Juan River basin, where some models have been developed. That modeling (Miller 2014) projected that the San Juan River population of Colorado pikeminnow could experience slight declines compared to current trajectory due to mercury, but those effects might be offset by the implementation of conservation measures that addressed other factors. The other threats were determined to have a more immediate and direct influence on the current status of the species and were thus considered as the primary threats to species' current and future condition. The SSA also evaluated the potential cumulative effects of these stressors (Service 2020, pp. 81 — 141). (USFWS, 2020a)

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SPECIES ACCOUNT: *Rhinichthys osculus lethoporus* (Independence Valley speckled dace)

Species Taxonomic and Listing Information

Listing Status: Endangered; October 10, 1989.

Physical Description

In general, speckled dace tend to be small (9 centimeters [3.5 inches]), and are distinguished by subterminal mouths, small scales, thick tails, and slender bodies (USFWS 2013). Coloration is typically olive green on the back, fading to silver/gold on the abdomen. As the vernacular name suggests, black spots may be randomly arranged over the body. A distinct black lateral stripe usually extends from the forebody to the caudal fin (54 FR 41448).

Taxonomy

The Independence Valley speckled dace (Rhinichthys osculus lethoporus) is a subspecies of speckled dace (Rhinichthys osculus), the result isolation that has led to genetic differences (ITIS 2015). The Independence Valley speckled dace is dwarfed, with a more laterally compressed body than is characteristic of speckled dace. Its lateral line is less developed, its caudal peduncle is deeper, and its pectoral fin rays are fewer than is typical of the Clover Valley speckled dace (R. o. oligoporus), its closest relative. It is also distinguished from the Clover Valley speckled dace by its straighter and more oblique mouth (54 FR 41448; USFWS 2008).

Historical Range

The exact historical distribution of Independence Valley speckled dace is unknown, but it is thought that they have only inhabited the Independence Valley Warm Springs Complex in Independence Valley, Elko County, Nevada. They occur throughout the marsh habitat within the Complex, primarily in areas with aquatic and emergent vegetation. (USFWS 2008; USFWS 2013).

Current Range

Surveys in 2008 found Independence Valley speckled dace distributed throughout the Warm Springs marsh, but rare or nonexistent near the spring outflows where nonnative largemouth bass (Micropterus salmoides) and bluegill (Lepomis macrochirus) were present. Federal and state biologists were denied access to the private property on which the Warm Springs Complex is located since from 2008 to 2019 (USFWS 2013). In 2020, Nevada Department of Wildlife was allowed access to survey the springs on the property. Dace were captured in two of the eight springs but nonnative species were documented in nearly every spring (NDOW 2020). The status of Independence Valley speckled dace in the wetland, the majority of the habitat for this species, is unknown as that has not been surveyed since 2008.

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: Independence Valley speckled dace are opportunistic omnivores. They are bottom browsers that feed primarily on small invertebrates (such as aquatic insects), plant material, and zooplankton. However, they will feed on large, flying insects at the water's surface and occasionally on eggs and larvae of other minnows when available. The Independence Valley speckled dace diet changes seasonally; they often eat algae and detritus in the fall, bottom-dwelling insects in winter and spring, and flying insects in the summer (USFWS 1998).

Reproduction Narrative

Adult: Generally, Independence Valley speckled dace sexually mature in their second summer. They are capable of spawning throughout the summer, but peak activity occurs in the months of June and July, at water temperatures of 18 °C (65 °F). Males congregate in spawning areas from which they remove debris to expose a bare patch of rock or gravel. The female is surrounded by males when entering a spawning area. Eggs are deposited underneath rocks, into spaces in the gravel, or close to the bottom; they are fertilized, and then hatch within 6 days. Independence Valley speckled dace typically live less than 4 years (USFWS 1998; 54 FR 41448).Eggs hatch in an average of 6 days; the larval fish, called fry, remain in the gravel for an additional 7 to 8 days. After emerging from the gravel, the fry tend to concentrate in the warm shallows of streams. Independence Valley Speckled dace live fewer than 4 years (USFWS 1998; USFWS 2015).

Geographic or Habitat Restraints or Barriers

Adult: It is believed that Independence Valley Speckled dace were forced out of an occupied stream due to predation by nonnative fish species such as rainbow trout (Oncorhynchus mykiss), largemouth bass (Micropterus salmoides), and bluegill (Lepomis macrochirus) (USFWS 1998)

Spatial Arrangements of the Population

Adult: Clumped according to resources.

Environmental Specificity

Adult: Broad/generalist or community with all key requirements common.

Tolerance Ranges/Thresholds

Adult: High; the species' adaptability to a broad range of environments enables it to persist in habitats too harsh for the survival of many other fish (USFWS 2013).

Habitat Narrative

Adult: Independence Valley speckled dace are able to occupy a wide variety of habitats—ranging from cold streams and rivers with rocky substrates to small thermal springs with silt substrates—and so have a high tolerance and broad environmental specificity. Independence Valley speckled dace are found in a permanent desert, freshwater stream/marsh fed by numerous springs. It is believed that Independence Valley speckled dace occupied the stream, but were forced out due to predation by nonnative fish species such as rainbow trout (Oncorhynchus mykiss), largemouth bass (Micropterus salmoides), and bluegill (Lepomis macrochirus) (54 FR 41448; USFWS 1998; USFWS 2015).

Dispersal/Migration

Motility/Mobility

Adult: Mobile

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Moderate

Immigration/Emigration

Adult: No

Dispersal/Migration Narrative

Adult: Independence Valley speckled dace are mobile, nonmigratory fish with a moderate dispersal rate (USFWS 1998).

Population Information and Trends

Population Trends:

Stable (USFWS 2013)

Species Trends:

Stable

Number of Populations:

One

Population Size:

Unknown; the current abundance of Independence Valley speckled dace is unknown. There have been no surveys in the wetland since 2008. In 2020, Nevada Department of Wildlife sampled three springs and captured speckeled dace at two springs. Only 11 fish were captured at one spring and 107 at the other (NODW 2020). Access to the private property on which the Warm Springs Complex is located was denied from since 2008-2019. The most complete surveys are still the ones completed in 2008 by USGS where 8,462 individuals were found (USFWS 2013). The spring and wetland complex where Independence Valley speckled dace are found has not been extensively surveyed since 2008 (Johnson et al. 2009). Staff employed by NDOW have conducted a few smaller scale monitoring surveys to document the continued presence of the species in the last few years. During the summer of 2020, NDOW staff set passive sampling minnow traps in three of eight previously monitored springs (NDOW 2020). The remaining springs were not sampled due to low water levels and/or the presence of non-native species. Independence Valley speckled dace were captured at one of the springs (11 dace) and in the outflow channel of another spring (107 dace) (NDOW 2020). Non-native species including largemouth bass (Micropterus salmonoides), American bullfrogs (Lithobates catesbeianus), and mosquitofish (Gambusia affinis) were also captured or observed which likely compete and predate on Independence Valley speckled dace. In the fall of 2022, NDOW set three minnow traps in the wetland and live trapped just over 300 Independence Valley speckled dace within 24 hours (NDOW 2022). The results of these surveys indicate that the species is still present in both the springs and wetland. However, the population size and distribution of the species in the springs and wetland remains unknown (USFWS, 2023).

Resistance to Disease:

Susceptible to disease brought in by nonnative fish (USFWS 1998).

Adaptability:

High; the species' adaptability to a broad range of environments enables it to persist in habitats too harsh for the survival of many other fish (USFWS 2013).

Population Narrative:

The current abundance of Independence Valley speckled dace is unknown; there have been no surveys in the wetland, which was previously identified as their main habitat, since 2008. In 2008 8,462 individuals were found. In 2020, Nevada Department of Wildlife sampled three spring sources but only captured 118 total speckled dace in two springs (NDOW 2020). The spring sources all contain nonnative aquatic species which may be limiting the population size of Independence speckled dace in those springs. Independence Valley speckled dace are susceptible to disease brought in by nonnative fish, but otherwise are adaptive to a broad range of environments; this adaptability enables it to persist in habitats too harsh for the survival of many other fish. Independence Valley speckled dace have moderate representation, and has low redundancy and resiliency (USFWS 2013).

Threats and Stressors

Stressor: Destruction of habitat (54 FR 41450)
Exposure: Reduced habitat, lower water levels.
Response:
Consequence: Reduction in population numbers, reduction in suitable habitat.
Narrative: The building and manipulation of reservoirs for irrigation was thought to be a serious threat, due to the reduction of available stream/outflow habitat and pond/reservoir habitat when water levels were regulated. In Independence Valley, no lands have been irrigated for crop production for the past 30 years. The reservoirs and stream outflows have not been used for irrigation for approximately the same amount of time. The landowner has stated that no plans exist for irrigation to occur on the property currently occupied by the fish. Existing land management practices, especially grazing management and modifications to the spring systems and marsh, have the potential to cause habitat destruction. Habitat destruction is especially detrimental to the Independence Valley speckled dace because of their limited distribution (USFWS 1998; USFWS 2013).

Stressor: Overutilization for commercial, scientific, or educational purpose (54 FR 41450)
Exposure: Collection of Independence Valley Speckled dace.
Response:
Consequence: Reduction in population numbers.
Narrative: At the time of listing, the small population size and limited distribution made Independence Valley speckled dace vulnerable to depletion by collection (USFWS 1998). It is thought that collection was detrimental to the populations of the Independence Valley speckled dace, and that this was one of the first things that caused this fish to become endangered. The 2008 5-year review stated that, although collection of this species is no longer a threat because it is no longer being done, its detrimental effect on population numbers remains (USFWS 2013).

Stressor: Nonnative fish (USFWS, 2013)
Exposure: Introduction of nonnative fish.
Response: Illness, increased vulnerability to predation.
Consequence: Reduction in population numbers.
Narrative: It is thought that establishment of nonnative fish in the Warm Springs Complex spring systems and marsh may provide an avenue for the introduction of diseases to which the Independence Valley speckled dace are not adapted. Predation from invasive fish also continues to be a threat to Independence Valley speckled dace (USFWS, 2013).

Stressor: Groundwater Withdrawl (USFWS 2008)
Exposure: Reduced habitat, lower water levels.
Response:
Consequence: Reduction in population numbers, reduction in suitable habitat.
Narrative: Groundwater withdrawal could severely reduce the amount of discharge from all spring systems occupied by the Independence Valley speckled dace (USFWS 2008). Reducing the discharge issuing from the springs could diminish valuable habitat and further limit the distribution of the fish. Mine development in the adjacent valley includes potential groundwater pumping that could reduce groundwater discharge in the spring system in which the Independence Valley speckled dace live.

Recovery

Reclassification Criteria:
The population at Independence Valley Warm Springs comprises at least two age classes, the population size is stable or increasing, and reproduction is documented for at least 3 consecutive years.

Nonnative fishes no longer adversely affect the long-term survival of the Independence Valley speckled dace.

Recovery Priority Number: 9C

Delisting Criteria:
Independence Valley speckled dace may be considered for reclassification from endangered to threatened when:

The population at Independence Valley Warm Springs comprises at least two age classes, the population size is stable or increasing, and reproduction is documented for at least 3 consecutive years.

Nonnative fishes no longer adversely affect the long-term survival of the Independence Valley speckled dace.

Independence Valley speckled dace occupy at least 75 percent of the total available habitat after enhancement, if needed, within the Independence Valley Warm Springs system.

The population exists at the aforementioned level (downlisting criteria) for a minimum of one generation (approximately 7 years).

Long-term protection of speckled dace populations from nonnative fish and other factors, and speckled dace habitat at Independence Valley Warm Springs is guaranteed.

Recovery Actions:

- Protection, restoration, and management of Independence Valley speckled dace habitats.
- Determination of Independence Valley speckled dace biology and their habitat requirements.
- Provide public information and education.
- Evaluate progress of recovery; revise management plans and recovery criteria.
-

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: The Service provides the following recommendations of recovery actions to focus on to aid the recovery of Independence Valley speckled dace: • Develop and implement a monitoring program that accounts for monitoring biases which can be used to detect changes in the status of the species. • Discuss potential habitat improvement projects with the private landowner that could mutually benefit their operational goals and the species. • Discuss the potential for cooperative agreements with the private landowner. • Evaluate the potential to minimize or remove the threat of non-native species (USFWS, 2023).

Additional Threshold Information:

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USFWS. 2023. 5-YEAR REVIEW Independence Valley Speckled Dace (Rhinichtys osculus lethoporus). Reno, Nevada. 4 pages.

SPECIES ACCOUNT: *Rhinichthys osculus nevadensis* (Ash Meadows speckled dace)

Species Taxonomic and Listing Information

Listing Status: Endangered; September 2, 1983 (48 FR 40178).

Physical Description

Ash Meadows speckled dace has a wide variety of body coloration within a population. Generally, the dorsum is olive-gray, blending ventrally to golden. Black spots frequently cover the body and there may be one or two distinct, black lateral strips. The maximum body length is 9.9 centimeters (3.9 inches) (USFWS 1990).

Taxonomy

Speckled dace are members of the minnow family of fishes (Cyprinidae). Various forms of speckled dace occur in many basins of western North America. Originally included with the Amargosa speckled dace group in 1893, this subspecies is now referred to as the Ash Meadows speckled dace because it is hydrographically isolated and occurs only in the Ash Meadows basin (USFWS 1990, 2014).

Historical Range

Previously known from at least ten springs and outflows in the Ash Meadows National Wildlife Refuge of Ash Meadows, Nye County, Nevada (USFWS 2014).

Current Range

The Ash Meadows speckled dace was formerly more widespread at Ash Meadows. Currently, it occurs in the following springs and their outflows: Jackrabbit Spring, Big Spring, and the two westernmost springs of the Bradford Springs group (NatureServe 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/2/1983.

Legal Description

On September 2, 1983 the U.S. Fish and Wildlife Service (Service) designated critical habitat for Rhinichthys osculus nevadensis (Ash Meadows speckled dace) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes three critical habitat unit (CHUs) in Nevada (48 FR 40178-40186).

The critical habitat designation for Rhinichthys osculus nevadensis includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Rhinichthys osculus nevadensis.

Critical Habitat Designation

The critical habitat designation for Rhinichthys osculus nevadensis includes three CHUs in Nye County, Nevada (48 FR 40178-40186).

Nevada, Nye County: Each of the following springs and outflows plus the surrounding land areas for a distance of 50 meters (164 feet) from these springs and outflows:

(1) Bradford Springs in Section 11, T18S, R50E, and their outflows for a distance of 300 meters (984 feet) from the springs.

(2) Jack Rabbit Spring and its outflow flowing southwest to the boundary between Section 24, T18S, R50E and Section 19, T18S, R51E.

(3) Big Spring and its outflow to the boundary between Section 19m T18S, R51E and Section 24, T18S, R50E.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. PCEs are not specified but are asusmed to be as follows (48 FR 40178-40186):

(1) Known constituent elements include warm-water springs and their outflows and surrounding land areas that provide vegetation for cover and habitat for insects and other invertebrates on which the species feeds.

Life History

Feeding Narrative

Adult: The Ash Meadows speckled dace prefer flowing streams where they feed on drifting invertebrates. Currently, there are several introduced species in the ecosystem that may compete for available resources (USFWS 1990).

Reproduction Narrative

Adult: The approximate lifespan of the Ash Meadows speckled dace is 4 years. Spawning can occur twice annually, once in the spring and again in late summer. Females broadcast eggs in stream riffle habitat, where they are fertilized and drift to the substrate (USFWS 1990).

Environmental Specificity

Adult: Narrow

Tolerance Ranges/Thresholds

Adult: Low

Site Fidelity

Adult: High

Habitat Narrative

Adult: Speckled dace generally prefer flowing freshwater streams in several warm springs of Ash Meadows. They occupy a very narrow habitat range; the ecological integrity of the community is low due to habitat destruction and invasive species (NatureServe 2015; USFWS 2014).

Dispersal/Migration

Motility/Mobility

Adult: Moderate

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low

Immigration/Emigration

Adult: Unlikely

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: The speckled dace is somewhat motile within a narrow range of only about 1.16 acres of occupied habitat. Historically, the habitat covered a wider range, but manipulation of springs and their outflows reduced the number of populations (USFWS 1990).

Additional Life History Information

Adult: Critical habitat for the speckled dace includes approximately 36 acres within warm springs of Ash Meadows. Currently, this subspecies only occurs in 1.16 acres of their original 599 acres of habitat (USFWS 1990). Manipulation of springs and their outflows decreased habitat connectivity and impacted the number of populations of the speckled dace.

Population Information and Trends

Population Trends:

Relatively stable (NatureServe 2015)

Species Trends:

Stable (USFWS 1990)

Population Growth Rate:

Stable

Number of Populations:

Four (USFWS 1990)

Population Size:

Estimated at 500 individuals in 1990 (USFWS 1990).

Minimum Viable Population Size:

Unknown

Resistance to Disease:
Unknown

Adaptability:
Low

Population Narrative:
The U.S. Fish and Wildlife Service categorizes the population status of the speckled dace as "stable." Currently, there are four known populations. The most current population estimate was 500 fish in 1990. Based on the extremely narrow range of the speckled dace and the small population size, the species has low resiliency, representation, and redundancy (USFWS 1990).

Threats and Stressors

Stressor: Habitat destruction
Exposure: Water development activities such as water diversion and excessive pumping have eliminated or degraded habitat.
Response: Increased stress on the species.
Consequence: Decrease in populations.
Narrative: Historic development of the water in Ash Meadows included water diversion and excessive pumping. These activities eliminated and degraded habitat, which decreased speckled dace populations (NatureServe 2015).

Stressor: Invasive fish, crayfish, and bullfrogs
Exposure: Introduction of several nonnative species into the habitat.
Response: Direct competition with and predation of the speckled dace.
Consequence: Reduced population size.
Narrative: Introduced species such as nonnative fish, crayfish, and bullfrogs have impacted speckled dace populations through competition and predation (USFWS 1990).

Stressor: Risk of extinction
Exposure: The speckled dace occupies a very narrow range and a specialized habitat.
Response: Increased stress on the species.
Consequence: Small populations and the narrow range of the habitat make the speckled dace vulnerable to extinction.
Narrative: The Ash Meadows speckled dace occupies an extremely narrow range and specialized habitat, which makes them especially vulnerable to all of the factors by which they may adversely affected (USFWS 1990).

Recovery

Reclassification Criteria:
All nonnative animals and plant species must be eradicated from essential habitat.

Secure and protect the Ash Meadows aquifer so that all spring flows return to historic discharge rates.

Reestablish water to historic springbrook channels which are free of barriers that eliminate genetic exchange between populations by preventing movement of native fishes throughout their historic range.

The essential habitat must be secure from detrimental human disturbances, including mining, off-road vehicles, and introduction of nonnative species.

Fish are present in all the springs that they have occupied historically.

Delisting Criteria:
The following criteria must be met for a minimum of 5 years:

All downlisting criteria must be met.

Reestablish aquatic communities to historic structure and composition in all essential habitat.

Each individual spring or stream population must have sex ratios and juvenile-to-adult ratios that support self-sustaining populations.

The listed Ash Meadows naucorid, the two candidate aquatic insects, and 13 candidate snails are present in all the locales that they have historically occupied.

Recovery Actions:
- Acquire and protect land and water within the Area of Management Concern.
- Secure and protect lands and surface and ground waters outside the Area of Management Concern but within Ash Meadows essential habitat.
- Secure and protect critical habitats.
- Return spring flows to historic channels.
- Enhance/restore terrestrial ecosystems.
- Enhance/restore aquatic ecosystems.
- Reestablish native aquatic communities.
- Reestablish four listed fish throughout their historic range.
- Minimize human disturbance.
- Monitor enhanced/reestablished populations.
- Determine factors controlling population size.
- Post signs that notify the public that the area is included within the National Wildlife Refuge System, and that activities are therefore subject to special regulation.
- Develop and implement water flow restoration plan.

Conservation Measures and Best Management Practices:
- RECOMMENDATIONS FOR FUTURE ACTIONS: (optional, but may be helpful to identify priorities for management actions and information needs for next 5-year review) 1. Monitor compliance with Nevada Revised Statute Order 1197A (January 12, 2018), Curtailment of New Appropriations of Groundwater within the Amargosa Valley Hydrographic Basin 230, that prohibits new applications for water or water diversions within 25 miles of Devils Hole (and by proximity Ash Meadows NWR). Water levels in Devils Hole are affected by pumping centers in the Amargosa Desert and the Ash

Meadows groundwater basins (Halford and Jackson 2020). 2. Collaborate with the Ash Meadows NWR to implement the Desert National Wildlife Refuge Complex – Ash Meadows, Desert, Moapa Valley, and Pahranagat National Wildlife Refuges Final Comprehensive Conservation Plan and Environmental Impact Statement, Volume I – August 2009 (Service 2009) and also the Draft Ash Meadows Natural Resource Management Plan in review (Service, in review); and 3. Support Ash Meadows speckled dace research at the Refuge and monitor the population as identified in the Recovery Plan for the Endangered and Threatened Species of Ash Meadows (Service 1990); and 4. Monitor the future activity of mineral rights in the Ash Meadows area. The BLM ACEC surrounding the refuge is withdrawn from mining and entry until 2029 (PLO# 7737, signed November 2nd, 2009), but requires renewal every 20 years. Mining can still occur on private inholdings within the refuge, but no active mining permits exist at this time. 5. Monitor the peer-reviewed literature of upcoming changes regarding the taxonomic uncertainties in the Death Valley forms of speckled dace, specifically the Ash Meadows speckled dace. (USFWS, 2021)

Additional Threshold Information:

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USFWS. 2021. 5-YEAR REVIEW Ash Meadows speckled dace (Rhinichthys osculus nevadensis). 9 pp.

SPECIES ACCOUNT: *Rhinichthys osculus oligoporus* (Clover Valley speckled dace)

Species Taxonomic and Listing Information

Listing Status: Endangered, October 10, 1989.

Physical Description

Speckled dace are distinguished by, among other characteristics, the shape and arrangement of pharyngeal teeth (usually slightly curved and hooked in a 1, 4-4, 1 formula) and the presence of well-developed radii completely around the scales. Coloration is typically olive-green on the back, fading to silver/gold on the abdomen. Black spots may be randomly arranged over the body, and a distinct black lateral stripe usually extends from the forebody to the caudal fin (54 FR 41448).

Taxonomy

Clover Valley speckled dace are members of the minnow family of fishes (Cyprinidae). Isolation of populations has permitted genetic divergence and resulted in a number of morphologically distinct forms recognized as subspecies. In general, speckled dace tend to be small—90 millimeters (3.5 inches) or less in total length—and are distinguished by subterminal mouths, small scales, thick tails, and slender bodies. The Clover Valley speckled dace is believed to be derived from an ancestral form of speckled dace similar to the Lahontan speckled dace presently occupying the Humboldt River system in northern Nevada. The Clover Valley speckled dace is distinguished from the Lahontan speckled dace by their less developed lateral line system on both the body and the head. The Clover Valley speckled dace is further distinguished by the anterior location of its pectoral fins and a lower number of pelvis fin rays. The Clover Valley speckled dace is distinguished from the Independence Valley speckled dace by a more developed lateral line, a more shallow caudal peduncle, and a greater number of pectoral fin rays. The Independence Valley speckled dace also has a straighter and more oblique mouth than the Clover Valley speckled dace (54 FR 41448; USFWS 2012).

Historical Range

Unknown (USFWS 1998).

Current Range

Clover Valley in Elko County, Nevada, is the only known location for the Clover Valley speckled dace. The species is known to occupy only three spring systems in the valley: Brandish Spring, Clover Valley Warm Springs, and Wright Ranch Spring (USFWS 1998).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Clover Valley speckled dace are omnivores. They feed primarily on small invertebrates, plant material, and zooplankton. They will also feed on large, flying insects at the water's surface, and occasionally on eggs and larvae of other minnows when available (USFWS 1998). Their food resources are widely distributed. Their activity rate is moderate because they are a diurnal species. Nonnative fish; rainbow trout were historically stocked in two of the three known populations, and low populations of Clover Valley speckled dace were noted. However, the specific interaction of the two species is unknown (USFWS 2012).

Reproduction Narrative

Adult: Clover Valley speckled dace have a demersal spawning reproductive strategy. They breed during the summer months and peak spawning occurs in June and July. Water temperatures of 18 °C (65 °F) and a gravel or rock substrate are required. Eggs hatch in approximately 6 days; fry shelter in the spawning substrate after hatching. Generally, speckled dace mature in their second summer (USFWS 1998). Reproductive fitness is moderate. The bases of the fins of both sexes turn orange to red during the breeding season, and males may or may not develop tubercles (bumps) on the pectoral fins (side fins behind gills) (USFWS 2012). They have a lifespan of less than 4 years (USFWS 2014).

Geographic or Habitat Restraints or Barriers

Adult: Clover Valley speckled dace are confined to springs and outflows of Clover Valley. Some springs have been ditched and impounded (NatureServe 2015).

Environmental Specificity

Adult: Narrow/ specialist.

Tolerance Ranges/Thresholds

Adult: Low

Site Fidelity

Adult: High

Dependency on Other Individuals or Species for Habitat

Adult: No

Habitat Narrative

Adult: Clover Valley speckled dace are found primarily in reservoirs and outflows of three spring systems: Clover Valley Warm Springs, Wright Ranch Spring, and Brandish Spring (USFWS 1998). They are confined to springs and outflows of Clover Valley, in which the springs have been largely ditched and impounded (NatureServe 2015). They have a very narrow environmental specificity, and the ecological integrity of their habitat is low. They have a low range/threshold and high site fidelity.

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Nonmigratory

Dispersal

Adult: Low; the three known populations are spatially discrete and exist in highly modified spring systems, located on private property (USFWS 2012).

Immigration/Emigration

Adult: No

Dependency on Other Individuals or Species for Dispersal

Adult: No

Dispersal/Migration Narrative

Adult: The Clover Valley speckled dace has low mobility and is nonmigratory. Dispersal is low. The three known populations are spatially discrete; they exist in highly modified spring systems, located on private property (USFWS 2012).

Population Information and Trends

Population Trends:

Stable (NatureServe 2015)

Species Trends:

Stable (NatureServe 2015)

Number of Populations:

3 (NatureServe 2015)

Population Size:

Nevada Deparment of Wildlife has conducted annual monitoring of each of the three sites from 2009-2020. The number of trapped fished has drastically declined at the Bradish and Warm Springs locations with only two to three fish captured at each location in the most recent surveys in the fall of 2020 (NDOW 2020). The number of fish captured at Wright Ranch Spring was 2,252 Clover Valley speckled dace.

Adaptability:

Low

Population Narrative:

Two out of the three populations of Clover Valley speckled dace have experienced drastic population declines with only 2-3 fish captured during the most recent survey in the fall of 2020 (NDOW 2020). The population at Wright Ranch Spring appears to be doing well with 2,252 fish captured in 2020. Comparisons of fish captured across years is limited due to changes in trapping effort through time but it appears that population is currently stable. The species has a moderate resiliency, but low representation, redundancy, and adaptability.

Threats and Stressors

Stressor: Habitat destruction
Exposure: Springs occupied by Clover Valley speckled dace have been impounded into reservoirs (USFWS 1998).
Response: Clover Valley speckled dace are restricted to habitats in the reservoirs, and seasonally in the outflows (USFWS 1998).
Consequence: The populations of Clover Valley speckled dace have been greatly reduced.
Narrative: Clover Valley speckled dace habitat has been modified by humans from an early date. Outflows from the springs occupied by the species have been impounded into reservoirs before being distributed to various irrigation ditches. Populations have been diminished due to the destruction of available habitat (USFWS 1998).

Stressor: Competition and Predation
Exposure: Nonnative sport fish are reported as preying on and/or outcompeting native fishes (USFWS 1998).
Response: Nonnative fish introductions are believed responsible for the loss of Clover Valley speckled dace from portions of their habitats (USFWS 1998).
Consequence: Population size of the Clover Valley speckled dace have diminished.
Narrative: Nonnative sport fish introductions have reportedly placed stress on Clover Valley speckled dace populations by preying on and/or outcompeting native fish. Consequently, Clover Valley speckled dace populations have been diminished in size and range (USFWS 1998).

Stressor: Climate Change
Exposure: Springs occupied by Clover Valley speckled dace experience flucations in water level due to drought, as well as flooding and sedimentation events due to nearby wildfires (Petersen 2020).
Response: Habitat available for Clover Valley Speckled dace reduced or eliminated due to drought conditions, wildfire, and sedimentation from flooding events (NDOW 2020).
Consequence: The populations of Clover Valley speckled dace have been greatly reduced with possible local extripation of two of the populations.
Narrative: Two out of the three populations of Clover Valley speckled dace have experienced drastic declines in number of fish caputured in the last several years. These declines maybe attributed to fluctating water levels and increased vegetation tied to drought conditions and sedimentation events linked to flooding after wildfire (NDOW 2020).

Recovery

Reclassification Criteria:
May be considered for downlisting to threatened when the population at each of the three springs (Clover Valley Warm Springs, Wright Ranch Spring, and Bradish Spring) comprises at least two age classes, the population size is stable or increasing, and reproduction is documented for at least 3 consecutive years (USFWS 1998).

Recovery Priority Number: 9C

Delisting Criteria:
May be considered for delisting, provided that all reclassification criteria have been met, and when (1) Clover Valley speckled dace occupy at least 75 percent of the total available habitat

after enhancement, if needed, within each spring system (Clover Valley Warm Springs, Wright Ranch Spring, and Bradish Spring); (2) the population exists at the aforementioned level (downlisting criteria) for a minimum of one generation (approximately 7 years); and (3) long-term protection of Clover Valley speckled dace populations and habitat is guaranteed (USFWS 1998).

Recovery Actions:

- Protection, restoration, and management of the Clover Valley speckled dace habitats (USFWS 1998).
- Determination of Clover Valley speckled dace biology and their habitat requirements (USFWS 1998).
- Provide public information and education (USFWS 1998).
- Evaluate progress of recovery and revise management plans and recovery criteria (USFWS 1998).
- Work with willing landowners to carry out recovery actions (USFWS 1998).
- Negotiate cooperative agreements with willing landowners in Clover Valley (USFWS 1998).
- Develop and implement habitat restoration/management plans (USFWS 1998).
- Develop and implement a monitoring program (USFWS 1998).
- Collect baseline information.
- Determine life history characteristics and habitat requirements for Clover Valley speckled dace (USFWS 1998).
- Develop and implement participation and outreach plans (USFWS 1998).

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS: Implementation of recovery actions are crucial to the recovery and conservation of Clover Valley speckled dace. Two of the three existing populations are experiencing critically low population numbers. To increase resiliency and redundancy for this species the populations at Clover Valley Warm Springs and Bradish Spring will need to be augmented or reestablished. Below are proposed actions by population that would help improve habitat conditions and inform decision making. Bradish Spring Work with private landowners and water rights owners to improve the spring outflow structure, remove sediment in the pond, and repair the dam structure to stabilize water levels and create more fish habitat (NDOW 2021) Wright Ranch Work with private landowners on habitat improvement projects that would prevent runoff of sediment during high flow events as well as improvements to the pond’s dam structure and water diversion infrastructure to ensure stability of water levels and speckled dace habitat (NDOW 2021). Clover Valley Warm Springs 1) Conduct water quality and sediment analyses necessary to identify potential sources of population decline; 2) Use the results of water quality monitoring and analyses to identify habitat improvement projects that should be implemented before fish are translocated from other populations; and 3) Work with private landowners on habitat improvement projects that would improve speckled dace habitat in the pond and outflow channel. All Locations 1) Continue to monitor the existing fish populations; 2) Continue discussions with private landowners and water right owners to explore the possibility of Safe Harbor Agreements and Conservation Easements; 3) Evaluate sampling protocols and modify the sampling approach to account for variation in capture ability and biases; 4) Evaluate genetic diversity of fish populations to inform decisions related to reintroduction efforts once habitat improvements are made; and 5) Reassess recovery criteria and suggest modifications if needed (USFWS, 2022).

Additional Threshold Information:

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SPECIES ACCOUNT: *Rhinichthys osculus thermalis* (Kendall Warm Springs dace)

Species Taxonomic and Listing Information

Commonly-used Acronym: KWS

Listing Status: Endangered; 10/13/1970; Mountain-Prairie Region (R6) (USFWS, 2016)

Physical Description

The KWS dace adults range in size from 0.9 to 2.1 inches (23 to 54 millimeters). Breeding males have been characterized as having a bright purple color while females are dull olive green (Hubbs and Kuhne 1937). However, Gryska (Gryska, 2006 pers. comm.) only observed the olive-green coloration during his research efforts although he handled many (several thousand) spawning males with nuptial tubercles. It is unknown why there has been an inconsistency in observations of the fish's breeding coloration (USFWS, 2015).

Taxonomy

The KWS dace was originally described as a subspecies of the western dace (Apocope osculus) (Hubbs and Kuhne 1937). Later work on the fishes of Wyoming designated the KWS dace as Rhinichthys osculus thermalis (Baxter and Stone 1995). The taxonomic certainty of the KWS dace as a distinct subspecies has been discussed by many investigators (Binns 1978; Gould and Kaya 1991; Hubbs and Kuhne 1937; Kaya et al. 1989, 1992; USFWS 1982). Gould and Kaya (1991) and Kaya et al. (1988, 1989, 1992) concluded that the KWS dace is a distinct subspecies (USFWS, 2015).

Current Range

The KWS dace is confined to one stream approximately 984 feet (300 meters) in length that originates at a series of thermal springs near the base of a bluff. The KWS area is located on the east bank of the Green River in the northwestern Wind River Range, approximately 30 air miles (48.5 kilometers) north of Pinedale, Wyoming (Figures 2, 3, 4, 5, 6). The habitat ends with a waterfall approximately three meters in height that plunges downward to the non-thermal Green River below. The KWS dace are believed to occupy their entire historic range (Kaya et al. 1992; Hubbs and Kuhne 1937). The warm springs themselves remain a constant 85°F (29.4°C) year-round. The stream, fed solely by the warm springs, is 984 feet (300 meters) in length and supports the world's only population of the KWS dace. The stream temperature is more variable than the warm springs and has been recorded as low as 78°F (25.6°C) in the winter at the point where it cascades over a waterfall into the Green River. The peripheral areas of the stream have been recorded as low as 52°F (11.1°C) in the winter. The warm nature of KWS indicates discharge from a deeply circulating flow system (Mattson 1998). Water emerging from the KWS may be circulating as deep as 2,953 feet (900 meters) indicating that it may be part of a deep regional ground water flow system. Typically, water associated with these systems has long flowpaths and moves slowly with residence times in the aquifer of centuries to millennia (Mattson 1998). Assuming that the springs discharge from a regional flow system, recharge may occur at some distance away from the springs' sources. This consideration is important when assessing potential impacts of projects on the population and its habitat.

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: KWS dace feed on benthic invertebrates and epiphytic organisms (Gryska and Hubert 1997). They suck and scrape invertebrates from the substrate by using a subterminal mouth specialized for benthic foraging. Benthic invertebrates occurring in the KWS stream include: Odonata (Argia, Erythemis), Trichoptera (Cheumatopsyche, Hydroptila), Coleoptera (Elmidae, Hydrophilidae), Diptera (Heleidae, Stratiomyiidae, Tendipedidae, Tipulidae), Amphipoda (Hyalella azteca), Hydracarina, and Gastropoda (Lymnaea, Planorbidae) (Binns 1978).

Reproduction Narrative

Adult: The KWS dace spawns year-round, although reproduction decreases in the winter (Gryska and Hubert 1997). During winter, very few larval fish are found along the shoreline, and the number of drifting larvae is substantially less in January than in May through August. Additionally, Gryska (1996) captured significantly fewer juvenile and adult fish in traps during winter than during summer. Mean length of fish captured in January was significantly greater than in summer (Gryska and Hubert 1997). The authors proposed two potential reasons for the seasonal changes they witnessed: (1) an overall reduction in primary productivity due to shorter winter days and reduced intensity of sunlight, and (2) cooler winter water temperatures in the shallow, near-shore larval fish habitat. It appears that photoperiod and/or water temperature may have an influence on reproductive rates (Gryska and Hubert 1997).

Habitat Narrative

Adult: The KWS dace is confined to one stream approximately 984 feet (300 meters) in length that originates at a series of thermal springs near the base of a bluff. The KWS area is located on the east bank of the Green River in the northwestern Wind River Range, approximately 30 air miles (48.5 kilometers) north of Pinedale, Wyoming (Figures 2, 3, 4, 5, 6). The habitat ends with a waterfall approximately three meters in height that plunges downward to the non-thermal Green River below. The KWS dace are believed to occupy their entire historic range (Kaya et al. 1992; Hubbs and Kuhne 1937). The warm springs themselves remain a constant 85°F (29.4°C) year-round. The stream, fed solely by the warm springs, is 984 feet (300 meters) in length and supports the world's only population of the KWS dace. The stream temperature is more variable than the warm springs and has been recorded as low as 78°F (25.6°C) in the winter at the point where it cascades over a waterfall into the Green River. The peripheral areas of the stream have been recorded as low as 52°F (11.1°C) in the winter. The warm nature of KWS indicates discharge from a deeply circulating flow system (Mattson 1998). Water emerging from the KWS may be circulating as deep as 2,953 feet (900 meters) indicating that it may be part of a deep regional ground water flow system. Typically, water associated with these systems has long flowpaths and moves slowly with residence times in the aquifer of centuries to millennia (Mattson 1998). Assuming that the springs discharge from a regional flow system, recharge may occur at some distance away from the springs' sources. This consideration is important when assessing potential impacts of projects on the population and its habitat. Most adult dace live in or along the main current of the stream, while dace fry are commonly found away from the primary flow. Small shallow pools located in beds of aquatic vegetation are well used by fry. Many small shallow pools are created by the hooves of elk and moose. The creation of the pools appears to be beneficial. Tiny, apparently newly hatched dace are common in all seasons (Binns 1978). Adult KWS dace inhabit fairly shallow pools and stream runs not more than one foot (0.31 meter) in depth. Plant growth within the water is necessary for escape cover and protection from the main current. Fry also use the vegetation as nursery areas (USFWS 1982). The KWS dace numbers along the creek seem to correlate with changes in dissolved oxygen and carbon dioxide levels. Fewer fish upstream and none at all at the spring source because dissolved oxygen is low and carbon dioxide is high. Plant growth provides their primary escape cover. A skittering flight to the nearest clump of plants is the typical predator avoidance reaction, although some also flee to the deeper, turbulent areas of the main current (Binns 1978). KWS dace were found to regularly drift over the waterfall and into the Green River during all months sampled (Gryska and Hubert 1997). Of those, 75 percent were larval fish and 25 percent were either juveniles or adults. Although the authors postulated that their estimates may have been low, they estimated that at least 75 larval fish per day drifted from the creek (a total of about 9,200 fish during the months of May through August). This was attributed to the relatively poor swimming ability of the larvae once they entered the swifter current. An estimated 24,000 larval fish were present in the stream in June (Gryska and Hubert 1997). Drift of juvenile and adult KWS dace from the stream was estimated to be 25 fish per day during the months of May through August (about 3,000 fish) (Gryska and Hubert 1997). Apparently the population has a high enough reproductive rate to withstand such emigration from the naturally occurring waterfall at the end of the habitat, since the population still exists at KWS. Habitat is limited, and only one population of the KWS dace exists. The habitat remains in relatively good condition; however, habitat alterations by recreational users have occurred in the form of construction of a series of dams/pools near the springs and also by contamination of the springs and stream by soaps, shampoos, and detergents. Since 1975 the U.S. Forest Service has prohibited bathing, wading, and washing clothes in the KWS area, but, rarely, illegal activities have been documented over the last several decades. At the time of its listing, its habitat was fragmented into two sections by a road built across the stream prior to 1934. The road culvert bisected the stream at a point approximately two-thirds of the way downstream from the stream's origin. The road culvert has since been removed and replaced with a bridge that spans the stream (USFS 1997) allowing reconnection of the habitat.

Dispersal/Migration

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory

Population Information and Trends

Population Trends:

Declining (USFWS, 2022)

Number of Populations:

One

Population Size:

200,000 to 500,000 fish (USFWS, 2022)

Population Narrative:

A technique was developed to observe trends in relative abundance of the Kendall Warm Springs dace population using Catch-per-Unit-Effort (catch/ trap) (Gryska and Hubert 1995, 1997). This method employs the use of 18 small unbaited traps evenly spaced along both sides of the stream. The traps are checked twice daily – in the morning and evening. Surveys were conducted in 1997, 1999, 2005, 2007, 2010, 2011, and 2013. The number of days surveyed per year has varied from 5 to 9 days. To be consistent, the survey has always been completed at the same time of year—mid June. Because the conditions at the spring remain fairly constant and the sample sizes are large, the Recovery Team believes that this methodology and CPUE data are sufficiently robust to indicate trends in relative abundance of the population. According to the survey results for trap years 1997 through 2013 (Figure 7, Anderson 2014, pers. comm.), KWS dace relative abundance may have declined during this time period. It is currently unknown if the observed changes in relative abundance are within the natural range of variability for the KWS dace. For complete survey methodology, see Gryska (1995) and Gryska and Hubert (1995, 1997). Studies to determine accurate estimates of the population size of the KWS dace or its prey base have not been attempted. To date, only CPUE studies for the dace have been employed indicating only trends in relative abundance over time. Mark-recapture experiments, if they were to be undertaken, could be used to estimate the dace's population size. However, mark recapture studies could stress fish causing mortality to some dace. Currently, because of the dace's listed status, a recovery permit would be required under Section 10 of the ESA and the effects to the species would have to be evaluated prior to issuance of a permit to conduct research. The actual abundance of adult KWSD has never been accurately estimated, but a rough assessment when the taxon was described suggested the population could be on the order of 200,000 to 500,000 fish (Hubbs and Kuhne 1937). No abundance estimates have been made since that time, although regular catch-per unit effort surveys have been conducted since the late 1990s. To track the population of KWSD, fish are sampled biennially in the stream below Kendall Warm Springs using live traps during the month of June. The overall capture rate in 2021 was similar to, though slightly lower than, the 2019 effort (USFWS 2022a). Overall, the KWSD population appears to be decreasing, as evidenced by long term declines in these relative capture numbers, resulting in average catch per unit effort currently less than 20 percent of what it was at its peak in 1999 (Figure 1). This decline is consistent and appears to represent an actual trend in the underlying abundance of KWSD, rather than noise due to trapping variation across the monitoring period. This continued downward trajectory, as well as a shift in population size structure (Figure 1), indicate continued reason to be concerned about the stability of the wild population (USFWS, 2022).

Threats and Stressors

Stressor: Bathing and the Use of Soaps, Detergents, Sunscreen, and Bleaches in the Species' Habitat
Exposure:
Response:
Consequence:
Narrative: Historically, recreational mountain travelers would bathe in the warm springs. It is reported that individuals also would wash clothes in the warm water of the springs (Binns 1978). The area was once a frequently-used recreational site. Swimming, bathing, and the use of detergents was believed to have degraded water quality and modified the quantity of vegetation present (Binns 1978). This threat occurred rangewide. At one time, this threat may have been of moderate to high intensity and may have resulted in mortality or inhibiting the basic needs of the

species. The use of soaps, detergents, sunscreens, or bleaches in the KWS has been prohibited by the U.S. Forest Service (USFS) since 1975 (Binns 1978) and signs posted onsite notify visitors of these prohibitions. Enforcement actions have occurred and appear to have been successful. As a result of the prohibitions and subsequent enforcement actions, the dace is currently believed to face insignificant exposure to this threat.

Stressor: Deleterious Effects of Research Efforts
Exposure:
Response:
Consequence:
Narrative: Research activities could stress the KWS dace population through reduction of habitat quantity and/or reduction in habitat quality. Researchers in their efforts to better understand the dace's habitat could enter the stream to analyze habitat and disturb the vegetation, the substrate and/or the invertebrates upon which the dace feed. The deleterious effects of research efforts are rangewide historic/future threats. The current exposure level for this threat is small. There are no current research efforts approved that could involve disruption or degradation of habitat. Permits are required by the Service, the USFS, and the Wyoming Game and Fish Department (WGFD) to perform research activities relating to the KWS dace. In the future, the potential deleterious effects (likely transitory and ephemeral) to the dace population from properly designed research efforts should be weighed against the benefits potentially derived leading to better informed recovery and management actions.

Stressor: Oil and Gas Development
Exposure:
Response:
Consequence:
Narrative: Oil and gas development has not been known to affect the KWS dace population in the past. Future oil and gas development could potentially stress the dace population through changing the spring water quantity (e.g., drying up the spring or decreasing flow) or water quality (e.g., altering temperature regime). Although Mattson (1998) estimated the potential recharge area of the spring to be an area 21,270 acres (8,593 hectares) in size, the exact recharge area of the spring is not known with certainty and could extend across multiple watersheds. Oil and gas development within the recharge area is a potential future threat. If this threat does materialize, the exposure level could be very significant as 100 percent of the population could potentially be exposed. Surface disturbance associated with drilling (construction of drill pads, roads, and use of drilling fluids) could introduce sediment and contaminants to the spring. Subsurface disturbance could occur if drilling intercepts the fault zone that supports the spring. Introduction of drilling fluids or intercepting water may affect the temperature of the spring water. Any of these changes could have adverse impacts on the Kendall Warm Springs dace (USFS 2000). Significant mortality and possible extinction of the species could be realized within a very short time. The USFS could authorize the Bureau of Land Management (BLM) to lease oil and gas development opportunities in the KWS area in the future. If leasing does occur, this could result in construction and operation of new well locations, upgrading of existing and building new roads, new pipelines, compressor stations, gas processing facilities, and evaporative ponds. Such development in the upper Green River watershed could impact crucial areas of KWS dace habitat and potential spring recharge areas. However, such activity would be subject to section 7 consultation under the ESA and impacts potentially resulting from this activity could be minimized as a result. The Mineral Leasing Act of 1920 directs that all public lands are open to

oil and gas leasing unless a specific order has been issued to close an area. At present, with no protection measures or decisions in place, the Federal land management agencies involved could authorize the development of oil and gas exploration and development activities within the potential recharge zone of the KWS. The withdrawal of 160 acres (64.75 hectares) around KWS from mineral entry (27 FR 8830, August 28, 1962) only applies to “locatable” minerals such as gold, silver, and precious metals and not to “leasable” minerals (oil and gas) or “salable” minerals (gravel, cobblestone, sand, etc.). Interest in oil and gas exploration and development on the Bridger-Teton National Forest has prompted evaluations of all potential impacts of USFS activities to the habitat of the KWS dace. In response to an increased interest in oil and gas drilling, Mattson (1998) conducted a hydrogeologic evaluation of the area surrounding the KWS. Mattson (1998) recommended that in order to protect the KWS dace from oil and gas development, a number of conservation measures and potential drilling restrictions should be implemented in the potential recharge area of KWS. The geologic environment surrounding KWS is complex and includes faulted and folded sedimentary rocks. The Wind River Mountains lie immediately east of KWS and were uplifted along the Wind River thrust fault. The mountain block shows evidence of shear zones in the interior of the mountain uplift. The younger strata on the west edge of the uplift are folded into a series of synclines and anticlines. A system of small high-angle reverse faults has further displaced and fractured the strata. The river corridor immediately surrounding KWS consists of a well-developed alluvial plain with unconsolidated glacial stream deposits. The complex geologic environment surrounding KWS gives rise to an equally complex hydrogeologic environment. The spring is apparently associated with a fault that delivers heated waters to the surface. Little detailed geologic investigation is available for the area, so it is difficult to precisely assess where recharge to the spring occurs (Mattson 1998). The 1990 Bridger-Teton National Forest Land and Resource Management Plan (BT Plan) identified these areas as being administratively available for oil and gas leasing (USFS 1990). The USFS 2000 draft Environmental Impact Statement (draft EIS) describes a proposal to authorize leasing activities within the vicinity of KWS (USFS 2000). However, the BT Plan did not make site-specific decisions concerning the leasing of these available lands. The Forest Supervisor of the Bridger-Teton National Forest did decide to not pursue oil and gas leasing in the areas analyzed in the draft EIS (USFS 2000) due to overwhelming opposition from the public (USFS 2003). No final EIS or Record of Decision has been developed or completed over the draft proposal. The draft EIS published by the USFS (2000) estimated that, over the approximately 369,900 acres (149,698 hectares) evaluated for potential oil and gas leasing activities, 30 to 128 wells could be expected to be drilled in the upper Green River area adjacent to where KWS is located (with associated facilities such as roads, pipelines, and power lines), if leasing were allowed. This scenario was developed using historical oil and gas development information from the U.S. Geological Survey (USGS), other known geologic information, and interpretation of information by the BLM and USFS geologists, as well as input from the oil and gas industry. Alternatives and stipulations for development evaluated in the draft EIS included: (1) a no development alternative, (2) allowing leasing within all areas analyzed, (3) using No Surface Occupancy (NSO) stipulations in all USFS roadless areas and areas where sensitive soils exists, (4) making unavailable the 21,270 acres (8,593 hectares) of potential recharge area of the KWS dace as evaluated by Mattson (1998), and (5) limiting the number of well pads to 1 per 160 acres (1 per 64.75 hectares). Currently the Kendall Warm Springs recharge zone remains available for construction and operation of drill sites. If these activities are permitted, this could result in the potential contamination, depletion, or change in water quality of the aquifer which supplies KWS. Such an irretrievable commitment of that water supply and recharge zone for KWS could cause the extinction of the KWS dace. Since interest in oil and gas development remains, these activities could eventually be approved and undertaken. If undertaken according to the draft EIS of the USFS (2000), the following project aspects would be expected to occur. All roads built or upgraded to access leases or facilitate field developments would be open to public traffic, except where administrative closures are in place. With field development, access roads may be plowed in the winter where and when possible, or may be accessed by over-the-snow vehicles. A total of 1,200 acres (485.6 hectares) around KWS could be recommended for withdrawal from locatable mineral entry as well as could carry a NSO Stipulation for leasable minerals. Acres of disturbance were estimated to be three acres for each well pad, and one mile of road and one mile of pipeline for each well, both located in the same corridor which would be 60 feet (18.3 meters) wide. During development (drilling), we assume that the area would receive high occupancy with high traffic use for approximately 90 days. However, this activity could occur for as much as 180 days. During production, we assume that one visit per well by pick-up truck would occur per day. Most emissions from oil and gas activities would be concentrated during the time period in which each well is being drilled and completed. This could extend from 3 to 6 months (USFS 2000). During the production phase (which could last 15 years or longer), dust from roads and pads would be expected to be substantially less than during the exploration and development phase. Pad sizes are typically smaller for production facilities, and vehicular use rates are typically much less. A producing field containing tank facilities, gas separation facilities, gas powered combustion compressor engines, diesel pumps, and other related equipment could produce odors due to the venting of gasses and other emissions. In the production phase, air pollutants such as carbon monoxide, hydrocarbons, nitrous oxides, sulfur dioxide, and hydrogen sulfide can be produced. The U.S. Environmental Protection Agency (EPA) states that a single well can produce in the vicinity of 250 tons (227 metric tons) of pollutants per year. These pollutants can be injected in the environment during disposal of liquid waste and unwanted gases by burning of waste products, and by fugitive loss of gases from storage tanks and other facilities. Accidental explosions, fires, blowouts, oil spills, and leaks cause potentially serious pollution problems as well (USFS 2000). The management area that contains the KWS dace and the springs' potential recharge area is predicted to have one of the highest potentials for projected oil and gas development as analyzed by the draft EIS (USFS 2000). Despite the current lack of interest on the part of USFS, having such a high potential for oil and gas development increases the likelihood of renewed interest in oil and gas drilling in the area. Fracturing of the substrata supporting the hydrologic conditions of the KWS could occur, unless proper conservation measures or lease stipulations are implemented. If plans for drilling in the area are pursued, the overall threat level for this threat could quickly become severe with immediate action being essential for survival of the KWS dace. Conservation measures to minimize this threat include making the 21,270 acres (8,593 hectares) of the springs' potential recharge area "administratively unavailable" for oil and gas leasing (Figure 8) (Mattson 1998).

Stressor: Presence of Livestock in the Habitat
Exposure:
Response:
Consequence:
Narrative: If allowed to enter KWS, livestock could affect the dace population through siltation of habitat and eutrophication of habitat. Livestock wading in the stream could cause some disturbance of the gravel and rock substrate of the stream bottom and allow some sediments to become suspended in the water or deposited in interstitial spaces that are critical for invertebrate production. Since the stream is relatively short (984 feet [300 meters] long) with a fairly rapid discharge of 6 to 8 cubic-feet-per-second (0.17 to 0.23 cubic-meters-per-second), it

would not be expected that much effect would be observed from the disruption of the stream bottom caused by only a few head of livestock present over a short time period. It would be expected that most suspended sediment would be flushed from the stream, over the falls, and into the Green River within a relatively short time. Livestock use of the stream could increase the quantity of nitrates, ammonia, or other inputs from manure and urination of the livestock in or adjacent to the stream. The extent of effects from this threat would depend on the number of livestock present and the duration of their stay. A fence regularly maintained by USFS excludes livestock from 160 acres (64.75 hectares) immediately adjacent to the stream.

Stressor: Increased Recreational Use of the Area
Exposure:
Response:
Consequence:
Narrative: The increase in recreational use of the area could lead to an increase in incidents of trespass and wading/bathing in KWS. Dace habitat could be modified by bathers seeking to increase the depth of the stream by excavating areas and constructing rock dams. People wading in the stream also could alter vegetation and stream beds. This is a potential rangewide threat that would be expected to have a low intensity. There have been a few citations issued in past decades by USFS law enforcement officers. However, we know of no recent habitat modifications or trespass into KWS by bathers.

Stressor: Reservoir Construction/Water Impoundments in the Upper Green River Watershed
Exposure:
Response:
Consequence:
Narrative: An impoundment in the watershed which supplies the recharge water for the KWS could potentially change both the quantity and quality of the water in KWS. Although unlikely at this time, a major water impoundment could completely inundate the KWS as has occurred to other thermal springs in Wyoming (e.g., Alcova Hot Springs currently inundated by Alcova Reservoir). If water quality or quantity of the KWS is changed, the dace would likely suffer significant mortality and potential extinction. Three potential reservoir sites on the upper Green River (Kendall, Wells, and Gannett) were mentioned in potential reservoir impoundment plans by a Wyoming Water Resources Research Institute study done in the late 1960s (Binns 1972 and N. A. Binns, pers. comm., June 15, 2007). Plans developed at that time indicated that a dam at the Kendall site could impound as much as 1 million acre-feet (1,233 million cubic meters), which would most certainly inundate KWS and the 984 feet (300 meters) of stream habitat occupied by the KWS dace. On May 17, 1968, an application was filed to the Wyoming State Engineer for a 608,600 acre-feet (750,403,800 cubic meters) capacity Kendall Reservoir (Binns 2007 pers. comm.). Public hearings on the proposed Kendall Dam were held in Pinedale and Green River City, where the proposal encountered considerable public resistance and the proposal was later shelved (Binns 2007 pers. comm.). Recently, there has been renewed interest in developing water storage facilities in the Upper Green River basin (P. Ogle, Wyoming Water Commission, pers. comm., April 3, 2011). This interest was focused on an area many miles downstream from the KWS area. Furthermore, the request for funding was denied for that proposal due to numerous conflicting resource issues. There are currently no approved plans to impound waters in areas that may affect the KWS area. If plans are developed for reservoir construction or water impoundments in the area, then the overall threat level could quickly change to one with severe effects.

Stressor: Catastrophic Wildfire
Exposure:
Response:
Consequence:
Narrative: The threat of catastrophic wildfire could represent a rangewide threat to the KWS dace. This is a future threat that could be of high intensity. Catastrophic wildfire in the forested area which recharges the KWS could cause hydrologic or thermal changes to the spring. This effect was seen lower in the watershed in the Surprise Lake area in Sublette County. There, a wildfire burned areas of the drainage and changed the temperature regime of the major spawning tributary of golden trout in the lake. The tributary was no longer suitable for golden trout spawning and the natural recruitment of that population declined (S. Roth, USFWS, pers. comm., February 15, 2007). Depending on the severity and intensity of a wildfire, burning of the forest could cause: (1) increased runoff rates from the surrounding mountainsides, (2) decreased infiltration of precipitation into the KWS recharge zone, and (3) siltation of the spring water of KWS. The KWS dace habitat is located in a sagebrush/grass vegetation type. Forested areas occur in the upper slopes of the recharge area for the KWS. Currently, the forest surrounding the KWS is predominantly lodgepole pine that is dying out due to pine bark beetle infestations. Fuel loading is typical for that region (5 to 20 tons/acre (11.2 to 44.8 metric tons/hectare)). The potential recharge area for the KWS is large (21,270 acres (8,593 hectares)) and the potential for a wildfire to occur there is moderate. Given the high public use of that area, suppression of any wildfires occurring there would be attempted at the earliest stages (P. Hutta, USFS, pers. comm., January 22, 2007). Furthermore, wildfire is a natural event in the ecosystem surrounding the KWS. It is likely that large fires have historically burned through the area on a periodic basis. Fire suppression efforts are not likely to occur in the area given the Forest Service conservation measures currently in place.

Stressor: Acid Rain
Exposure:
Response:
Consequence:
Narrative: An increase of pollutants in the air could lead to a change in the pH of the rain water/snowmelt which recharges the KWS. A change in pH caused by acid rain could be a threat of regional scope affecting multiple states. It is unknown if effects from this threat are currently affecting the KWS dace population. Given the increase in industrialization of Sublette County, Wyoming, and the concomitant concern with decreasing air quality (Thuermer, Jr. 2014), it is conceivable that acid rain could alter the water chemistry of KWS. Prevailing winds may transport pollutants from industrialized regions. It is anticipated that the acid rain, if it occurred in the KWS dace area, would be of low intensity. Also, the spring water is alkaline and emits from a limestone formation supplying calcium anions to the spring water (Binns 1978). Therefore, the spring may be fairly insulated from any threat from acid rain. Presently, no evidence of acid rain affecting the spring is known.

Stressor: Herbicide/Pesticide Use
Exposure:
Response:
Consequence:

Narrative: The use of herbicides for weed control could affect the KWS dace habitat in the near future. Some non-native weed species are present in the immediate vicinity of KWS. Treatment of these with herbicides, if not appropriately conducted, could lead to localized contamination of the dace's habitat, a decrease in aquatic vegetation of the habitat, and a reduction in invertebrate numbers leading to decreased habitat suitability for the dace. Even a brief exposure to a weak solution could prove lethal to the dace. A weak solution in the stream also could damage or destroy algae and phytoplankton, thus altering the basic productivity of the stream and degrading the food chain upon which the dace depend. Similarly, pesticide use, if not conducted properly, could be lethal to the dace or damage or destroy aquatic benthic invertebrates, as well as zooplankton, upon which the dace feed. Because potential applications of herbicides or other pesticides near the dace's habitat are under the control of USFS and section 7 consultation requirements apply to this activity, we have ranked the overall threat level of this threat as low. The ESA, requires USFS to consult with the Service prior to activities which they determine "may affect" a listed species. It is assumed that a well-planned protocol to minimize or eliminate adverse effects to the dace would be developed during section 7 consultation between USFS and the Service prior to the use of either herbicides or pesticides near the dace's habitat.

Stressor: Climate change
Exposure:
Response:
Consequence:
Narrative: Scientific evidence currently indicates that the increase in greenhouse gases in the Earth's atmosphere caused by the burning of fossil fuels such as coal, oil, and natural gas are having a worldwide effect on the Earth's climate. Worldwide temperatures have risen over the past century and that trend is expected to continue. With worldwide warming, the polar ice caps and montane glaciers are melting at accelerated rates and below normal precipitation is occurring in many areas (Barry and Seimon 2000; Hall and Fagre 2003; Thomas et. al. 2009). The magnitude of warming in the northern Rocky Mountains has been particularly great, as indicated by an 8-day advance in the appearance of spring phenological indicators since the 1930s (Cayan et al. 2001). The hydrologic regime in the northern Rockies also has changed with global climate change and is projected to change further (Bartlein et al. 1997; Cayan et al. 2001; Stewart et al. 2004). Under global climate change scenarios, the mountainous areas of northwest Wyoming may eventually experience milder, wetter winters and warmer, drier summers (Bartlein et al. 1997). Additionally, the pattern of snowmelt runoff also may change, with a reduction in spring snowmelt (Cayan et al. 2001) and an earlier peak runoff (Stewart et al. 2004), so that a lower proportion of the annual discharge will occur during spring and summer. Our analyses under the ESA include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other

variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change. Future climate change will be the product of natural variability acting over multiple spatial and temporal scales superimposed on anthropogenic trends (Gray et al. 2003, 2004; Jackson et al. 2009). Predicting ecological and biogeographic responses to climate change constitutes an immense challenge for ecologists (Jackson et al. 2009; Romme and Turner 1991). The effect that climate change could have on the KWS dace is unknown at this time. The KWS dace currently inhabits water which is geothermally warmed to a temperature of around 29.4°C (85°F). A drastic increase in the temperature of the spring water could lead to thermal or hydrologic changes to the springs that could be out of tolerance limits to the dace population. Lower precipitation levels potentially caused by global climate change could lead to reduced flows of the KWS and a reduction of available habitat for the dace. Climate change is a potentially imminent and future threat. However, there is a large degree of uncertainty regarding what the localized effects of climate change will be and how localized effects may potentially impact the dace and its habitat. The warm nature of KWS indicates discharge occurs from a deeply circulating flow system. Typically such deep regional flow systems have long flowpaths and move slowly. Residence times are typically centuries to millennia (Mattson 1998. Further studies should be conducted to determine if there is a need for strategies to monitor and minimize the effects of this potential threat.

Stressor: Illegal Taking of the Dace
Exposure:
Response:
Consequence:
Narrative: The following are threats caused by the overutilization of the KWS dace for commercial, recreational, scientific, or educational purposes: Illegal taking of the dace for home aquaria or for other commercial trade purposes could cause reduction of KWS dace numbers. To date, this has not been an issue since no illegal taking of the dace has been documented. If illegal take has occurred, it appears that the population has not been impacted. However, in other parts of the world, other rare and endangered species have been exploited for food, medicinal, or ornamental properties. Some are sold locally or internationally to rare species collectors pushing those species closer to extinction. Potential exists for similar activity to occur to the KWS dace. Any illegal collections of the dace would be presumed to be of low intensity with a small portion of the population exposed to such efforts.

Stressor: Deleterious Effects of Research Efforts
Exposure:
Response:
Consequence:
Narrative: By visual observations from the stream-side, the population appears robust. The habitat appears to be completely occupied and the fish breed year-round. Because there are some unknown aspects of the dace's biology, there is a high probability that some KWS dace or their invertebrate prey will be utilized for scientific purposes in the future. Some research efforts may include attempts at captive rearing or population monitoring. Successful captive rearing or establishment of refugia populations will depend on learning the breeding requirements of this species in captivity. If this is undertaken, it will require field capture of individuals and acclimatization to a laboratory setting. It is likely that some individuals will die from trapping mortality or disease. It is unlikely that individuals removed from the KWS dace population for

captive rearing studies would be returned to KWS because doing so would risk the introduction of any diseases contracted in the laboratory to the KWS population. Studies to determine accurate estimates of the population size of the KWS dace or its prey base have not been attempted. To date, only CPUE studies for the dace have been employed indicating only trends in relative abundance over time. Mark-recapture experiments, if they were to be undertaken, could be used to estimate the dace's population size. However, mark recapture studies could stress fish causing mortality to some dace. Currently, because of the dace's listed status, a recovery permit would be required under Section 10 of the ESA and the effects to the species would have to be evaluated prior to issuance of a permit to conduct research.

Stressor: Use of Kendall Warm Springs Dace as Bait Fish
Exposure:
Response:
Consequence:
Narrative: The KWS dace were historically used as bait fish; although it is uncertain to what extent this activity occurred in the past. The WGFD prohibited the use of KWS dace as bait beginning in the 1960s. This was a rangewide historical threat with an unknown past exposure level. Depending on the extent of its capture by anglers, anywhere from a small part of the population to a very significant part of the population may have been impacted. Death would be assumed to be the response of KWS dace used as bait fish.

Stressor: Disease Stemming from Research Efforts
Exposure:
Response:
Consequence:
Narrative: Deleterious effects from disease could be realized as a result of research efforts. Equipment or waders used in habitat during dace population assessment could serve as pathways for the introduction of disease into the population. This is a rangewide threat that could occur under current management procedures. Precautions are now taken to minimize the risks of disease being introduced into the KWS dace population. Current research protocol calls for all equipment and waders used for research efforts in the habitat of the KWS dace be disinfected with a 10% bleach solution before entering the habitat. If disease were to be introduced into the population, potentially 100% of the KWS dace population could be affected. Depending on the type of disease introduced, the response from individuals could range from behavioral to significant mortality or extinction.

Stressor: Disease or Predation of Dace From Introduction of Non-native Species
Exposure:
Response:
Consequence:
Narrative: Historically, disease or predation has not been an issue as no introduced species or diseases have been documented in the habitat of the KWS dace. Potential exists for illegal introduction of warmwater or tropical fishes into the habitat of this species. Introduced fish diseases or predators to the KWS could have devastating effects on the KWS dace population potentially affecting 100 percent of the population. Introduced predatory fishes could affect the dace population and lead to extinction of the species. The overall level for this threat is high. Refugia populations are needed to ensure survival of the KWS dace should disease or predation by non-native species jeopardize the only dace populations currently in existence. Many

examples exist of other fish restricted to one location that have gone extinct at least partially caused by non-native species introductions. The Wyoming Game and Fish Commission currently prohibits the introduction of non-native fishes to KWS or any waters of the State; but illegal introductions of non-native fish species still do occur (Rahel 2000; WGFD 2012a, b). Aquatic non-native species legislation (Enrolled Act 62, see WGFD 2010) was passed by the Wyoming legislature in 2010, substantially increasing the potential penalties for introducing non-native aquatic species into waters of the State. A program to prevent the expansion of aquatic non-native species also was started as a result of the recently passed legislation. We commend the State of Wyoming for enacting such laws prohibiting the introduction of non-native species within the State. However, it is uncertain, at this time, how successful this legislation will be at completely preventing such introductions. Because illegal introductions could still occur despite laws aimed at stopping them and because such introductions could have devastating effects on the only KWS dace population, we conclude this is a high intensity threat with potential for very significant exposure of the species and potentially causing significant mortality or extinction.

Stressor: The Inadequacy of Existing Regulatory Mechanisms
Exposure:
Response:
Consequence:
Narrative: Although many regulatory mechanisms are currently in place independent of the ESA and have been fairly effective at controlling some of the deleterious threats that historically affected the dace, additional regulatory mechanisms could be improved for further protection of the dace. For instance, a regulatory mechanism in the BT Plan to protect the recharge zone for KWS from potential oil and gas development by making the area “administratively unavailable” is not currently in place, but has been discussed (USFS 2000). The high-level threat of oil and gas development in the spring’s recharge zone is discussed under Factor A above. The following is a general synopsis of all existing regulatory mechanisms (independent of the ESA) currently employed and their inadequacies, if applicable. Prohibitions currently exist against: (1) wading, bathing, or the use of soaps or detergents for washing clothes in the KWS and associated stream habitat; (2) livestock use of the stream for watering purposes; (3) introductions of non-native species into the habitat of the dace; (4) mining or staking locatable mineral claims in a 160-acre (64.75-hectare) area surrounding the KWS habitat; (5) the use of KWS dace as baitfish (WGFD 2012a); and (6) fishing in the KWS area (WGFD 2012c). These existing regulatory mechanisms are important and help protect the species. The enforcement portion of some regulatory mechanisms may be a key issue in some cases. The difficulty of complete and adequate enforcement of regulations in a remote setting like KWS may put the dace at risk. Although prohibited since 1975, some wading and bathing in the spring has still occurred. The USFS conducted a population survey of the KWS dace in 2005. During that survey, four of the traps used to capture the dace were tampered with. One trap disappeared completely during a day set (was the most visible from the road), two traps were partially stepped on (presumably by a small, hoofed animal), and one was removed from the stream and placed atop an algae mat. Five dace were found dead in that trap (USFS 2006). These instances demonstrate the difficulty of ensuring that KWS dace are protected from illegal activities. However, to our knowledge such events have been relatively rare. The 1990 Bridger-Teton National Forest Land and Resource Management Plan includes a goal to protect populations of, and provide suitable and adequate amounts of habitat for the KWS dace (USFS 1990). The plan also states that the existing populations and habitat of the KWS dace will be maintained and enhanced (USFS 1990). Included in the activities that are likely to take place during implementation of the plan are a KWS dace

exclosure fence and fence reconstruction activities (USFS 1990). Livestock are currently prohibited from entering KWS and an exclusion fence is regularly maintained by the USFS. These measures are currently believed to be fairly effective at excluding livestock from KWS. However, livestock have occasionally gained access to the springs for watering. Those situations involved: (1) downed portions of the exclusion fence, (2) low water levels in the Green River due to drought conditions allowing livestock to swim across the Green River, or (3) low water levels in the Green River allowing cattle to walk or wade around the portion of the fence which extends to the edge of the Green River. Therefore, regular monitoring of fences and livestock use are necessary to ensure the protections enacted remain effective. To date, no non-native species are known to have been introduced into KWS. However, numerous thermal springs throughout North America have received unauthorized introductions of non-native species causing disastrous consequences for the native dace species there (see Table 1 below), making precautions at KWS appropriate. Possible factors contributing to KWS not yet having received unauthorized non-native species introductions are: (1) the low publicity level of the KWS area; (2) the inaccessibility of the area to the general public during much of the year due to winter road closures; (3) Wyoming regulations against the use of live baitfish along the Upper Green River; and (4) prohibitions against the introduction of non-native species in the State (WGFD 2012b). Also, coldwater fish species in the adjacent Green River may not survive the warmer water temperatures found in KWS. In 2010, the Wyoming Legislature established an Aquatic Invasive Species Program to combat the threat of illegal aquatic introductions in Wyoming. This effort is aimed at zebra mussels (Dreissena polymorpha) and quagga mussels (Dreissena rostriformis) that have continued to spread throughout North America, despite intense efforts to stop their range expansion, causing major changes to aquatic ecosystems where these species have been introduced. Vigilant enforcement of restrictions on illegal non-native aquatic species introductions is necessary, but the complete elimination of the threat from non-native species introductions (e.g., tropical aquarium fish, etc.) may be highly difficult because this crime may not be discovered until long after it is committed. Although the area surrounding KWS has been withdrawn from locatable mineral entry (27 FR 8830, August 28, 1962), the possibility still remains that fluid mineral mining (oil and gas development) or salable mineral mining (e.g., pea gravel, gravel, cobblestone) could still be authorized in the KWS recharge zone which has been estimated to be 21,270 acres (8,593 hectares) in size (Mattson 1998). A prohibition, if put in place, against fluid or salable mineral development in the spring's recharge zone would provide needed administrative protections from these threats to the dace's habitat. A Kendall Warm Springs Biological Unit Management Plan was approved by USFS in 1978. The management objectives of that plan were to: (1) maintain or improve the quality and quantity of the presently occupied habitat, and (2) to perpetuate a viable population level of dace. The area designated by this plan encompasses 160 acres (64.75 hectares). This same acreage was withdrawn from locatable mineral entry under EO-10355 in 1962, fenced to provide habitat protections in 1969, and identified as "essential habitat" for the dace in 1977. Boundaries include most of the small watershed and adjacent terrestrial communities which surround and directly affect the spring and stream section (USFS 1978). The 1978 plan provides a good description of the taxonomy and ecology of the dace. Several threats are addressed in the plan and recommendations were made in the plan to address those threats. Several follow-up actions since 1978 have been employed. The U.S. Forest Service Bridger-Teton National Forest Land and Resource Management Plan, approved in 1990, covers the known population of dace (USFS 1990). The BT Plan contains general standards and guidelines for the maintenance and enhancement of the KWS dace habitat. More specific conservation measures such as making the recharge area of KWS "administratively unavailable" for oil and gas development (USFS 2000), if approved and finalized, would serve to alleviate this threat. The Bridger-Teton National Forest began the revision process for its Land and Resource Management Plan in 2005. However, that revision process has been put on hold pending ongoing litigation over forest-planning rules. Therefore the conservation measure designating the potential recharge of KWS as "administratively unavailable" has, to date, not yet been implemented. The current inadequacy of some existing regulatory mechanisms is a rangewide threat with a moderate intensity as opportunities to more effectively regulate activities affecting the species may be missed.

Stressor: Other Effects Stemming From Introduction of Non-native Species
Exposure:
Response:
Consequence:
Narrative: Other Natural or Manmade Factors Affecting the Species' Continued Existence: The introduction of non-native fish or other aquatic species to the spring could upset the ecological balance currently present in the spring ecosystem thereby potentially impacting the KWS dace or potential hybridization could destroy the genetic integrity of this unique subspecies (Dowling and Childs 1992; Echelle and Conner 1989). Competition for food, shelter, breeding sites, or competition for other resources could occur as a result of the introduction of non-native species. Small populations of other dace species occurring in thermal springs in other areas of North America have been severely impacted, been partially extirpated, or become extinct, because of the introduction of non-native species (see Table 1) which were able to survive in the warm waters that those dace historically inhabited (Deacon et al. 1964; Lanteigne 1987; McAllister 1969; Nico 2006; Nico and Fuller 2006; Renaud and McAllister 1988; USFWS 2006). The nearest thermal spring to KWS where there are documented cases of introduced non-native species is Kelly Warm Springs located to the northwest in Teton County, Wyoming. Kelly Warm Springs, which is inhabited by the more common speckled dace (Rhinichthys osculus), currently contains introduced populations of guppies (Poecilia reticulata), convict cichlids (Cichlasoma nigrofasciatum), green swordtails (Xiphophorus helleri), bullfrogs (Rana catesbeiana), red rim snails (Melanoides tuberculatus), and tadpole madtoms (Noturus gyrinus) (Grand Teton National Park 2009; Nico 2006; Nico and Fuller 2006). Convict cichlids pose a threat to small native fish because of their predatory nature. Guppies pose a threat to native fish because not only are they a hardy, prolific competitor, but they also can carry non-native trematode parasites (Nico 2006). They also are effective predators of larval fish (e.g., potentially KWS dace fry). According to Deacon et al. (1964), convict cichlids, in combination with other non-native fishes, apparently caused the decline and extermination of a population of speckled dace (R. osculus) near Lake Mead, Nevada. The speckled dace (Rhinichthys osculus) occurs in the Green River adjacent to KWS. In other environments, speckled dace have hybridized with other cyprinid minnows (e.g., least chubs (Iotichthys phlegethontis (Miller and Behnke 1985), redside shiners (Richardsonius balteatus) (Baxter and Stone 1995), and longnose dace (Rhinichthys cataractae) (Smith 1973)). If speckled dace were able to persist in the thermal environment of the KWS stream, then an introduction of the speckled dace, either deliberate or without malicious intent, could have significant implications for the genetic integrity of the KWS dace population through intraspecific hybridization. Similar effects have occurred to the Pecos pupfish (Cyprinodon pecosensis) (Echelle and Connor 1989), the Apache trout (Oncorhynchus apache), and the Gila trout (O. gilae) (Dowling and Childs 1992) through the introduction of allopatric conspecifics. We know of no studies involving KWS dace undertaken to identify whether or not incidents of intraspecific hybridization have occurred in the past. Though we rank the exposure level of this threat as currently small, the intensity level could be high given the potentially significant implications for

the preservation of genetic integrity of this unique subspecies and because the ability to detect genetic contamination by speckled dace is very low given the size of the occupied habitat and lack of genetic monitoring currently employed. The potential upset of the ecological balance of the KWS ecosystem by the introduction of one or more non-native species or the potential loss of the genetic integrity of the KWS dace through introduction of other Rhinichthys species if it occurred would be a rangewide threat. Any introduction of nonnative species could presumably affect 100 percent of the KWS dace population since the dace is only found in one locality. The KWS dace population could suffer significant mortality or other deleterious effects. Enforcement of regulations and laws associated with illegal non-native species introductions and apprehension of perpetrators after the fact also are decidedly difficult. Action should be undertaken to lessen the potential impacts associated with this threat. After a thorough evaluation of potential effects to the KWS dace population, attempts at controlling any introduced non-native species could potentially be employed by implementing one or more removal strategies.

Stressor: Activities of Vandalism
Exposure:
Response:
Consequence:
Narrative: Potential exists for deliberate poisoning of the KWS dace or the purposeful introduction of deleterious non-native species into its habitat. Poisoning could occur through the application of piscicide or other contaminant(s). Because it is only found in one location, the entire population of the KWS dace could be eliminated by such an action. To date, there is no indication that anyone or any group would attempt to vandalize the KWS dace population. This is a rangewide threat which has the potential to affect 100 percent of the population, and since only one population of the KWS dace exists, this could lead to its extinction. We rank the intensity of this threat as high, but with only a small exposure to the population at this time. Action is needed to reduce the degree of the dace's vulnerability to this potential threat possibly by establishing refugia populations that would not be exposed to such a threat.

Stressor: Threats Associated with Small Population Size and Restricted Geographic Range
Exposure:
Response:
Consequence:
Narrative: Stochastic, or random, changes in a wild population's demography or genetics, can threaten its persistence (Brussard and Gilpin 1989; Lacy 1997). A stochastic demographic change such as a skewed age or sex ratio (for example, a sudden loss of adult females) could negatively affect reproduction, especially in a small population. Species with small population size and restricted distribution are vulnerable to extinction by natural processes and human disturbance (Levin et al. 1996). Random events causing population fluctuations or population extirpations become a serious concern when the number of individuals or the geographic distribution of the species is very limited. A single human-caused or natural environmental disturbance could destroy the entire population of KWS dace. When a population's genetic variability falls to low levels, its long-term persistence may be jeopardized because its ability to respond to changing environmental conditions is reduced. In addition, the potential for inbreeding depression increases, which means that fertility rates and survival rates of offspring may decrease. Although environmental and demographic factors usually supersede genetic factors in threatening species viability, inbreeding depression and low genetic diversity may enhance the probability of extinction of rare species (Levin et al. 1996). Because there is only one population of KWS dace

in one geographic area, any detrimental impacts which are negatively affecting the population are affecting the entire KWS dace population. The lack of more than one KWS dace population may increase the likelihood of its extinction. Establishing refugia populations has been discussed; to date, no refugia populations have been established. The KWS dace have never been documented to reproduce in captivity. Their captive rearing would be very important to the establishment of refugia populations.

Stressor: Toxins
Exposure:
Response:
Consequence:
Narrative: Toxins may enter the KWS ecosystem in a number of ways. Potential sources of toxins include: (1) the use of soaps, detergents, sunscreens, or bleaches in the KWS, (2) vehicle use on the bridge which crosses the KWS ecosystem, (3) road construction/maintenance activities, (4) fire suppression activities, or (5) oil and gas development. Effects to dace could include: (1) direct poisoning, (2) impaired reproduction of the species, or (3) poisoning of the dace's food supply. As this dace occurs in only one location, this threat is considered a rangewide threat. At one time, the use of soaps, detergents, and bleaches may have been of moderate/high intensity. The use of such materials has been prohibited since 1975. The dace currently are not known to be exposed to this threat. The use of vehicles on the bridge over the dace's stream habitat could affect the dace population if: (1) a toxic spill occurs, (2) garbage is dumped, or 3) road salt or sediment is washed from the road into the stream. There have been no instances recorded of this activity historically occurring. Because: (1) the road which crosses the bridge over the dace's stream habitat is the only access road to the heavily used Green River Lakes recreational area and campground and because (2) recreational use of the area is likely to increase in the future, this threat could have more potential to affect the dace in the future. Depending on the extent of any inputs into the stream this could be a low/moderate threat. It is expected that up to 30% of the population would be affected, since only the lower one-third of the dace's habitat is downstream from the bridge crossing. Some habitat could be modified or dace mortality could occur as a result of poisoning. If a wildfire occurred in the recharge zone for the KWS, the fire suppression activities associated with that wildfire could have deleterious effects to the KWS dace population. Fire suppression activities could include increased vehicle traffic around the springs and the use of fire retardants. Fire retardants are often composed of either ammonia nitrate or surfactants. Ammonia nitrate is toxic to fish and could enter the spring water and poison the dace, or reduce or eliminate the aquatic plants or invertebrates present in the KWS. Fire retardant use is banned within the 160-acre fenced exclosure around KWS as per the Fire Management Plan for the Bridger-Teton National Forest (J. Neal, USFS, pers. comm. 2008, 2011). The USFS also has recently agreed to implement a 0.5 mile mandatory fire retardant application buffer around KWS to further reduce the possibility that a misapplication could occur near KWS (USFS 2011). Toxins from oil and gas development have not been known to have stressed the KWS dace population in the past. However, toxins associated with this activity could stress the dace population in the future through impacts to the underground aquifer. The scope of the threat of oil and gas development is rangewide. The exact recharge area of the spring is not known with certainty and could extend across multiple watersheds. Currently no deleterious effects from oil and gas development are realized by the population as this is a potential threat. If this threat does materialize, the exposure level would be very significant as 100% of the population could be exposed. Significant mortality and possible extinction of the species could be realized within a short time. If drilling in the area is pursued, the overall threat level for this

threat could quickly become severe with immediate action being essential for survival of the KWS dace. Conservation measures to minimize this threat have not yet been committed to by the relevant agencies. Proposed conservation measures include making the 21,270 acres (8,593 hectares) of the springs' potential recharge area "administratively unavailable" for oil and gas leasing (Mattson 1998).

Stressor: Other Natural Events
Exposure:
Response:
Consequence:
Narrative: The potential for earthquakes, seismic activity, or great floods exists within the dace's habitat. The area is within an Intensity VII Earthquake Area (Case et al. 2002). The U.S. Geologic Survey (USGS) estimated that a 4.2 to 4.5 magnitude earthquake might occur somewhere in the Green River Basin every 62 years (BLM 1999, as cited in BLM 2004). The effects an earthquake of this magnitude might have on Kendall Warm Springs remains unknown however. The Yellowstone National Park region, located about 60 miles to the northwest, is a hotspot for geothermal, seismic activity and some major volcanic eruptions have occurred there in the past. The intensity of this threat if it were to occur could potentially be very high with a very significant exposure level and 100 percent of the KWS dace population could be affected. Significant mortality could result. Currently, the population is not known to be experiencing any effects from this threat and the likelihood is low that deleterious effects would materialize from this threat.

Recovery

Reclassification Criteria:
The population of KWS dace and its habitat are shown to be protected by the effective implementation of a no drilling zone (e.g., buffers, administratively unavailable areas, withdrawals, etc.) that significantly reduces the threats associated with the introduction of toxins (petroleum products or fracking fluids) to its habitat by oil and gas extraction activity that could intercept the spring recharge zone that supplies water to its habitat. These protections should be assured through formal inclusion as regulatory mechanisms in an approved land management plan or other regulatory means.

The population of KWS dace and its habitat are shown to be protected by the effective implementation of a no drilling zone (e.g., buffers, administratively unavailable areas, withdrawals, etc.) that significantly reduces the threats associated with manipulation of the spring's flow (and associated hydrologic regime) or thermal regime by interception of the water table from oil and gas exploration activities in the spring's recharge zone. These protections should be assured through formal inclusion as regulatory mechanisms in an approved land management plan or other regulatory means.

The naturally-occurring KWS dace population is experiencing a stable or increasing trend in relative abundance over a five-year period as indicated by Catch per Unit Effort (CPUE) survey methodologies or other methods as determined by the Recovery Team.

A captive KWS dace population is established and successfully propagated and maintained in at least one location, including complete documentation of propagation methods and hatchery requirements. The captive population will consist of the number of individuals and pairs that will ensure the maintenance of long-term genetic diversity and integrity necessary for long-term species viability as documented in the best available scientific information.

Recovery Priority Number: 12C

Delisting Criteria:
The population of KWS dace and its habitat are shown to be protected from present and foreseeable threats to the point where listing is no longer required through implementation of activities including stewardship, protection of groundwater in the spring recharge zone, and ensuring adequate regulatory enforcement. These protections should be assured through formal inclusion as regulatory mechanisms in an approved land management plan or other regulatory means.

The naturally-occurring KWS dace population is experiencing a stable or increasing trend in relative abundance over a ten-year period as indicated by Catch per Unit Effort (CPUE) survey methodologies or other methods as determined by the Recovery Team.

Necessary administrative measures are implemented to ensure flows are maintained. Suitable flows and water quality in the KWS stream are determined through recovery tasks and assured through formal inclusion as regulatory mechanisms in an approved land management plan or other regulatory means.

Captive KWS dace populations are established and successfully propagated and maintained in at least two locations, including complete documentation of propagation methods and hatchery requirements. Captive populations will consist of the number of individuals and pairs that will ensure the maintenance of long-term genetic diversity and integrity necessary for long-term species viability as documented in the best available scientific information.

Non-native species, if present, are controlled within the KWS ecosystem and are not causing declining trends in relative abundance of the KWS dace population there. Additionally, develop and implement a management strategy to monitor the site for the presence of non-native species and promptly take action to address any concerns from any non-native species for which presence has been verified. This management strategy should be formally adopted by incorporation as a regulatory mechanism in an approved land management plan or other regulatory means.

Recovery Actions:
- Protect KWS dace habitat and establish formal regulatory mechanisms in an approved land management plan, or other regulatory means. 1.1 Develop/revise and implement a habitat protection plan. A plan should comprehensively identify specific protection parameters and threats to the water quality/quantity and habitat of the KWS dace (Priority 1b). 1.2 Protect and maintain the hydrology for the estimated recharge zone for KWS to provide for continual uninterrupted flow of the springs, particularly from the threat of oil and gas development in the recharge zone. Work toward the inclusion of oil and gas development protection measures within the spring’s recharge zone during the revision of the Bridger Teton National Forest Land and Resource Management Plan (Priority 1a). 1.3 More thoroughly verify the source and recharge zones of the aquifer that supports stream flow in

KWS. Perform comprehensive investigation, mapping, and modeling so that effective groundwater management and conservation is ensured (Priority 1b). 1.4 Monitor and maintain stream flow, water quality, and channel morphology in natural conditions to provide for ecosystem functions to support KWS dace. A USFS Land and Resource Management plan that serves to improve watershed health should be developed and implemented for the protection of the watershed supporting KWS dace (Priority 1a). 1.5 Identify and eliminate potential pollution sources to aquatic habitats of the KWS dace to the maximum extent practicable. Of special concern are potential inputs from oil and gas development (Priority 1a). 1.6 Through both field and laboratory investigations, determine flow velocities, temperatures, extent/amount of habitat needed, and water quality tolerances and preferences of different life history phases (including reproduction) of KWS dace. The information gained will be used in the establishment of the refugia populations. Information on factors that may influence these habitat requirements includes the impacts of vegetation in spring outflows, assessment of aquatic and riparian vegetation cover, and water flows and water levels. The information should be analyzed by season, age class, and stream section. Some information has already been gathered in this area. Qualitative assessments of habitat preferences have been made, suggesting the adults occupy areas with 33 moderate depths and velocities, and gravel substrates near aquatic vegetation and the fry occupy shallower, backwater areas. Future investigations will be predicated on sufficient numbers in the wild to allow for experimentation without affecting the population (Priority 2). 1.7 Investigate the effect of disturbance in the system as it relates to the needs of the fish. Complete research to determine the effects of various land management methods (e.g., grazing practices) in the riparian area around KWS (Priority 3). 1.8 Enforcement of existing regulations to protect habitat should be continued (Priority 1a).

- . Enhance KWS dace habitat. 2.1 Develop a habitat enhancement plan. A habitat enhancement plan for KWS aimed at improving and maintaining physical habitat for KWS dace should be formulated and implemented. This may include the physical alteration of stream morphology. A number of anthropogenic habitat modifications occurred during the past century including: partially damming the stream after the construction of a road across the stream, placement of road culverts within the streambed and their subsequent removal, the construction of wading pools within the stream by the building of small rock dams, the watering of livestock within the spring and the subsequent construction and maintenance of a fence around the spring to exclude livestock (Priority 2).
- 3. Protect KWS dace from catastrophes. 3.1 Prepare a KWS dace catastrophe plan. The plan should be implemented if necessary to ensure the continued survival of this species if a catastrophe occurs (Priority 1a).
- 4. Protect KWS from the threat of non-native species. 4.1 Minimize potential introduction of non-native species. Protective measures that minimize the possibility that non-native competitors, predators, and/or carriers of parasites and/or diseases remain out of the ecosystem should be developed and employed. Potentially introduced species within the range of the KWS dace are a major potential threat and alleviating this threat will require ongoing enforcement of State regulations and keeping the habitat as little publicized, as possible. Potential problems could include not only non-native fishes, but also other non-native animals or plants that could introduce a parasite or disease or alter the natural habitat. Because of the dangers of predation, competition, diseases, parasites, and hybridization, introductions of all non-native organisms that could affect the aquatic environment, should be prevented within the range of the KWS dace. Methods for control should be developed and implemented for non-native species that could potentially be

detrimental to the KWS dace population or its habitat. Declines, extirpations, and extinctions of several other dace species are attributable to negative impacts by introduced non-native fishes (Priority 1a). 34 4.2 Strict regulations on use and enforcement and movement of baitfish are currently in place and should be continued (Priority 1a). 4.3 All equipment and waders used for research efforts in the habitat of the KWS dace should be disinfected with a 10 percent bleach solution, or best available decontamination method before entering the habitat (Priority 1b).

- 5. Maintain KWS genetic structure. 5.1 Develop and implement a genetics management plan. A genetics management plan should be completed in accordance with the Service's Captive Propagation Policy. The purpose of the plan is to ensure that: (1) the genetic makeup of propagated individuals is, to the extent practicable, representative of the wild population; (2) propagated individuals are behaviorally and physiologically suitable for introduction; and, (3) this genetic makeup is maintained in captivity over generations. The genetics management plan should include adaptive management provisions to incorporate biological information gained during the research and early implementation of captive propagation (Priority 1b). 5.2 Evaluate the species' genetic structure. The results should help in the management of the population(s). This information will be essential for establishment of captive populations and the maintenance of genetic diversity. Evaluate any changes in the variation in the KWS dace' genetic structure and/or morphology by comparing current specimens to the original type-specimens collected in the 1930s. It is possible that the dace in KWS has undergone bottleneck effects as a result of its use as baitfish from the 1930s to the 1960s prior to the prohibition of its use as bait (Priority 1b). 5.3 Preserve genetic integrity. There is only one population of KWS dace. For genetic diversity tracking purposes, the population of KWS dace in KWS will be considered one management unit. Any additional established populations will be considered separate management units (Priority 1b).
- Protect KWS from extinction by establishing refugia populations. 6.1 Maintain refugia populations of KWS dace in captivity to lessen the risk of extinction by a catastrophic event. These refugia populations should be in a facility that can maintain the population for the long term, can maintain the genetic characteristics of the source population, and is secure. Specific details on holding facilities should be developed and their establishment should be pursued by designated individuals. Refugia populations should be maintained in manmade habitats (either indoor or outdoor) or aquaria, as necessary. Artificial refugia are an important component of the effort to preserve several endangered or nearly endangered fish species (Pister 1981; Johnson and Jensen 1991; Weedman 1998). These refugia should preserve a large fraction of the genetic variability originally present in their progenitors (Turner 1984). Captive populations may be established at facilities managed by a variety of groups (schools, museums, public education displays, zoos, National Fish Hatcheries, 35 etc.). The level of genetic diversity in the population will, in part, determine the number of fish that need to be housed in captivity. Dexter National Fish Hatchery and Technology Center has played a major role in the recovery programs for other species. Other captive populations of threatened fish are held at zoos, museums, and universities (Bagley et al. 1991; Brown and Abarca 1992; Weedman 1998). Since these populations may have high fluctuations in size and structure, periodic genetic reviews of currently maintained captive populations also must be implemented (Priority 1b). 6.2 It is important to establish at least 2 additional stocks that contain the genetic diversity of the species. Identify and select two potential sites (Priority 1b). 6.3 Protocols should be developed for capture, transport, establishment, and management of the KWS dace refugia populations (Priority 1b). 6.4 An important aspect of the success of the genetic conservation management plan is the

continued monitoring of the refugia populations. The KWS dace introduced into refugia need to be maintained and monitored for survivability, health, growth, and reproductive success. Additional KWS dace need to be periodically stocked in the refugia to maintain the genetic diversity of the stock (Priority 1b). 6.5 Prior to any captive population establishment efforts, a comprehensive introduction plan should be developed in accordance with the Service’s Captive Propagation Policy (Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act, 65 FR 56916, September 20, 2000). This plan would include, but not be limited to, a consideration of population genetics, an assessment of reintroduction effects should reintroduction become necessary in Kendall Warm Springs, and a specific monitoring component to measure reintroduction results (Priority 2).

- 7. Continue KWS dace monitoring efforts. 7.1 Maintain a population and habitat database and generate regular reports. The USFS is designated as the repository agency for habitat and population monitoring data. Regular reports should be generated and distributed to other interested parties involved in the management of the KWS dace. Data is stored at the Pinedale Ranger District Office of the Bridger-Teton National Forest and is available to cooperating partners. Standardized population and habitat monitoring protocols have been established and implementation of those protocols should continue. A consistent report format should be adopted to allow rapid analysis of comparable data from reports over time (Priority 3).
- Implement post-delisting monitoring. 8.1 Develop a post-delisting monitoring plan for the KWS dace. Section 4(g)(1) of the ESA requires that the Service monitor the status of all recovered species for at least 5 years following delisting. In keeping with this mandate, a post-delisting monitoring plan should be developed by the Service in cooperation with WGFD, USFS, other Federal agencies, academic institutions, 36 and other appropriate entities. This plan should outline the indicators that will be used to assess the population status of the KWS dace, develop monitoring protocols for those indicators, and evaluate factors that may trigger consideration for relisting (Priority 3).
- Apply Adaptive Management. 9.1 The strategy of this recovery plan is based on the best available science; however, we recognize there are considerable knowledge gaps regarding the species and the ecosystem upon which it depends. As a result of this uncertainty, the process of KWS dace recovery will necessitate adaptive management. Throughout the implementation of recovery actions outlined below, new information and technologies will become available. New information should be evaluated and used to modify the strategy for recovery of KWS dace, as appropriate. With increasing knowledge, some recovery actions will likely become obsolete and other actions will be proposed that cannot be envisioned now. Likewise, the objectives and criteria of this recovery plan may be adjusted in the future as our understanding improves. Through a continual circular process of biological planning, conservation design, conservation delivery, outcome-based monitoring, assumption-based research, evaluation, and adjusting management, we will learn how to effectively conserve this species. The knowledge we gain from implementation of this recovery plan will be incorporated in the future recovery process. The Service periodically reviews approved recovery plans to determine the need for modifications. This recovery plan should be considered a living document that is flexible and consistent with the available, contemporary, scientific information. This may require periodic updates to the plan without full revisions being completed. This flexibility will maximize the usefulness of the recovery plan. The adaptive management concept ensures that all parties who choose to participate will have opportunities to contribute to the KWS dace recovery process. The work to accomplish the species’ recovery should be coordinated with multiple agencies. Only by

working together with different resources, knowledge, and expertise can recovery objectives and criteria be achieved (Priority 2).

- 10. Perform Life history studies (predicated on sufficient numbers of fish in the wild to allow for experimentation without affecting the population). Information on life history will be useful to ensure adequate husbandry needs for captive populations. 10.1 Determine the population structure of the KWS dace. Determine population viability, optimum numbers and the spatial arrangement of the population, and population dynamics including fecundity, age and size class, sex ratio and longevity, through population estimations (Priority 1b). 10.2 Study interactions with coexisting organisms. Investigations of competition will require additional knowledge of reproduction, life history, habitat use, and food preference. The KWS dace is thought to eat invertebrates and algae; 37 however, virtually nothing is known of specific food preferences. Potential predators of KWS dace include dragonfly nymphs (Odonata), American dippers (Cinclus mexicanus), and wandering garter snakes (Thamnophis elegans vagrans) (Priority 3). 10.3 Perform laboratory studies on spawning habitat, embryo development, and habitat preferences for yolk-sac larvae, feeding larvae, and juveniles of KWS dace. Perform further field observations on spawning adults and habitat preference of larvae, juveniles, and adults. Comprehensive studies in laboratory and field settings are needed to determine reproductive traits such as timing, duration, frequency, behavior, fecundity, and habitats (including water velocities, depths, and substrate). This information can be used to assist in developing captive breeding techniques for maintaining captive populations and assessing potential competition. This information also could be critical to management of the ecosystem to benefit reproduction of the species. Important factors could be discovered that are currently limiting the reproduction and early survival of KWS dace (Priority 1b). 10.4 Investigate predation by other organisms and incorporate information obtained into management of the population. Predation levels by all co-habitating organisms should be determined for KWS dace through field study (Priority 3). 10.5 Investigate disease and parasites. No data are available on the diseases and parasites of the KWS dace. Advancing knowledge of the diseases and parasites of the fish could help contain any potential future epidemic (Priority 1b).
- 11. Cooperate with stakeholders/partner agencies and formalize expectations of continued stakeholder/partner cooperation in an approved land management plan. 11.1 Seek and maintain a team relationship with partners. Endorse and encourage the partnerships of agencies and stakeholders to continue protection of the KWS dace and its habitat. Approval and support of governmental agencies and grazing lessees are needed. These entities should be recognized for past land management actions that have allowed the species to persist (Priority 1b). 11.2 Thoroughly evaluate all proposed projects prior to beginning any study (Priority 1b).
- A Kendall Warm Springs Biological Unit Management Plan was approved by USFS in 1978. The management objectives of that plan were to: (1) maintain or improve the quality and quantity of the presently occupied habitat, and (2) to perpetuate a viable population level of dace. The area designated by this plan encompasses 160 acres (64.75 hectares). This same acreage was withdrawn from locatable mineral entry under EO-10355 in 1962, fenced to provide habitat protections in 1969, and identified as "essential habitat" for the dace in 1977. Boundaries include most of the small watershed and adjacent terrestrial communities which surround and directly affect the spring and stream section (USFS 1978). The 1978 plan provides a good description of the taxonomy and ecology of the dace. Several threats are addressed in the plan and recommendations were made in the plan to address those threats. Several follow-up actions since 1978 have been employed. The U.S. Forest Service

Bridger-Teton National Forest Land and Resource Management Plan, approved in 1990, covers the known population of dace (USFS 1990). The BT Plan contains general standards and guidelines for the maintenance and enhancement of the KWS dace habitat. More specific conservation measures such as making the recharge area of KWS "administratively unavailable" for oil and gas development (USFS 2000), if approved and finalized, would serve to alleviate this threat. The Bridger-Teton National Forest began the revision process for its Land and Resource Management Plan in 2005. However, that revision process has been put on hold pending ongoing litigation over forest-planning rules. Therefore the conservation measure designating the potential recharge of KWS as "administratively unavailable" has, to date, not yet been implemented. The current inadequacy of some existing regulatory mechanisms is a rangewide threat with a moderate intensity as opportunities to more effectively regulate activities affecting the species may be missed.

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Continue population monitoring (with the possible addition of quantifying fry abundance and/or distribution within the stream) 2. Include monitoring of KWSD habitat, specifically to include quantification of watercress in the vegetation component of that monitoring. 3. Implement annual maintenance removal of watercress. 4. Continue the development and genetic management of captive refugia KWSD populations. 5. Revisit efforts to implement administrative measures to protect Kendall Warm Springs from oil and gas development pressures (USFWS, 2022).

References

USFWS 2016. Status of the Species and Critical Habitat: Rhinichthys osculus thermalis (Kendall Warm Springs dace). U.S. Fish and Wildlife Service 2600 SE 98TH Ave., Suite 100. Portland, OR 97266. Provided to FESTF from Chris Mullens 9/30/2016.

NatureServe. 2015. NatureServe Central Databases. Arlington, Virginia, U.S.A.

U.S. Fish and Wildlife Service. 2015. Recovery Plan for the Kendall Warm Springs Dace (Rhinichthys osculus thermalis). Revision: Original Approved July 12, 1982. U.S. Fish and Wildlife Service, Cheyenne, Wyoming.

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USFWS. 2015. Recovery Plan for the Kendall Warm Springs Dace (Rhinichthys osculus thermalis). Revision: Original Approved July 12, 1982. U.S. Fish and Wildlife Service, Cheyenne, Wyoming.

USFWS. 2022. 5-YEAR STATUS REVIEW Kendall Warm Springs dace (Rhinichthys osculus thermalis). Wyoming Ecological Services Field Office. 9 pages.

SPECIES ACCOUNT: *Salmo salar* (Atlantic salmon)

Species Taxonomic and Listing Information

Critical Habitat Designated

Yes;

Life History

Food/Nutrient Resources

Dispersal/Migration

Population Information and Trends

Threats and Stressors

Stressor:
Exposure:
Response:
Consequence:
Narrative:

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

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References

SPECIES ACCOUNT: *Salvelinus confluentus* (Bull Trout)

Species Taxonomic and Listing Information

Commonly-used Acronym: None

Listing Status: Threatened/Experimental Population, Non-Essential; 06/10/1998, 12/09/2009; Pacific Region (R1) (USFWS, 2016)

Physical Description

Bull trout has pale yellow, orange, or salmon-colored spots on an olive green to bronze back. These spots do not appear on the dorsal (back) fin. The bull trout's tail is not deeply forked as is the case with lake trout (Salvelinus namaycush).

Taxonomy

Genus - Salvelinus (Richardson 1836); Species- Salvelinus Confluentus (ITIS 2015).

Historical Range

The historical range of bull trout includes major river basins in the Pacific Northwest, from the southern limits in the McCloud River in northern California and the Jarbidge River in Nevada; to the headwaters of the Yukon River in the Northwest Territories, Canada (USFWS 2015b).

Current Range

The bull trout’s current range includes Puget Sound; various coastal rivers of British Columbia, Canada; and southeast Alaska. Bull trout occur in portions of the Columbia River and tributaries within the basin, including its headwaters in Montana and Canada. Bull trout also occur in the Klamath River basin of south-central Oregon. East of the Continental Divide, bull trout are found in the headwaters of the Saskatchewan River in Alberta and Montana, and in the MacKenzie River system in Alberta and British Columbia, Canada (USFWS 2015b).

Distinct Population Segments Defined

Yes, there are five Distinct Population Segments: Klamath, Columbia, St. Mary-Belly Rivers, Jarbridge, and Coastal-Puget Sound (USFWS 2008).

Critical Habitat Designated

Yes; 10/18/2010.

Legal Description

On October 18, 2010, the U.S. Fish and Wildlife Service (Service) designated revised critical habitat for Salvelinus confluentus (Bull trout) under the Endangered Species Act of 1973, as amended (Act) (75 FR 63898 - 64070). This critical habitat replaced critical habitat designated on October 6, 2004, for the Klamath River and Columbia River bull trout populations (69 FR 59995 - 60076) and on September 26, 2005, for the Klamath River, Columbia River, Jarbidge River, Coastal-Puget Sound, and Saint Mary-Belly River populations (70 FR 56212 - 56311). On July 1, 2009, the U.S District Court for the District of Oregon granted the Service's request for a voluntary remand of the 2005 final rule, with direction to complete a new proposed rule. The 2010 critical habitat designation includes 32 critical habitat units (CHUs) in Idaho, Montana, Nevada, Oregon and Washington.

Critical Habitat Designation

The critical habitat designation for Salvelinus confluentus includes 32 CHUs in Adams, Benewah, Blaine, Boise, Bonner, Boundary, Butte, Camas, Custer, Elmore, Gem, Idaho, Kootenai, Lemhi, Lewis, Nez Perce, Owyhee, Shoshone, Valley, and Washington Counties, Idaho; Deer Lodge, Flathead, Glacier, Granite, Lake, Lewis and Clark, Lincoln, Mineral, Missoula, Powell, Ravalli, and Sanders Counties, Montana; Elko County, Nevada; Baker, Clatsop, Columbia, Deschutes, Gilliam, Grant, Harney, Hood River, Jefferson, Klamath, Lake, Lane, Linn, Malheur, Morrow, Multnomah, Sherman, Umatilla, Union, Wallowa, Wasco, and Wheeler Counties, Oregon; and Asotin, Benton, Chelan, Clallam, Clark, Columbia, Cowlitz, Garfield, Grant, Grays Harbor, Island, Jefferson, King, Kittitas, Klickitat, Mason, Okanogan, Pend Oreille, Pierce, Skagit, Skamania, Snohomish, Stevens, Thurston, Wahkiakum, Walla Walla, Whatcom, Whitman, and Yakima Counties, Washington. A total of 31,750.8 km (19,729.0 mi) of stream (including 1,213.2 km (754.0 mi) of marine shoreline) (Table 1), and 197,589.3 ha (488,251.7 ac) of reservoirs and lakes (Table 2) are designated as bull trout critical habitat (75 FR 63898-640702).

A. Coastal Recovery Unit (1) Olympic Peninsula

(2) Puget Sound

(3) Lower Columbia River Basins

(4) Upper Willamette River

(5) Hood River

(6) Lower Deschutes River

(7) Odell Lake

(8) Mainstem Lower Columbia River

B. Klamath Recovery Unit (9) Klamath River Basin

C. Mid-Columbia Recovery Unit (10) Upper Columbia River Basins

(11) Yakima River

(12) John Day River

(13) Umatilla River

(14) Walla Walla River Basin

(15) Lower Snake River Basins

(16) Grande Ronde River

(17) Imnaha River

(18) Sheep and Granite Creeks

(19) Hells Canyon Complex

(20) Powder River Basin

(21) Clearwater River

(22) Mainstem Upper Columbia River

(23) Mainstem Snake River

D. Upper Snake Recovery Unit (24) Malheur River Basin

(25) Jarbidge River

(26) Southwest Idaho River Basins

(27) Salmon River Basin

(28) Little Lost River

E. Columbia Headwaters Recovery Unit (29) Coeur d’Alene River Basin

(30) Kootenai River Basin

(31) Clark Fork River Basin

F. Saint Mary Recovery Unit (32) Saint Mary River Basin

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Salvelinus confluentus critical habitat consists of nine components in Idaho, Montana, Nevada, Oregon and Washington (75 FR 63898-64070):

(i) Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.

(ii) Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.

(iii) An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

(iv) Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.

(v) Water temperatures ranging from 2 to 15 degrees Celsius (°C) (36 to 59 degrees Fahrenheit (°F)), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.

(vi) In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.

(vii) A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.

(viii) Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

(ix) Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas within the geographic area occupied by the species at the time of listing contain the features that are essential to the conservation of the species and may require special management needs or protection. Accordingly, in identifying critical habitat in occupied areas, we assess whether the PCEs within the areas determined to be occupied at the time of listing may require any special management considerations or protection. Although the determination that special management may be required is not a prerequisite to designating critical habitat in areas essential to the conservation of the species that were unoccupied at the time of listing, all areas we are designating as critical habitat require some level of management to address current and future threats to bull trout, to maintain or enhance the physical or biological features essential to its conservation, and to ensure the recovery of the species. The primary land and water management activities impacting the physical or biological features essential to the conservation of bull trout that may require special management considerations within the critical habitat units include timber harvest and road building (forest management practices), agriculture and agricultural diversions, livestock grazing, dams, mining, and nonnative species (Beschta et al. 1987, p. 194; Chamberlin et al. 1991, p. 194; Furniss et al. 1991, p. 297; Meehan 1991, pp. 6–10; Nehlsen et al. 1991, p. 4; Sedell and Everest 1991, p. 6; Craig and Wissmar 1993, p. 18; Frissell 1993, p. 350; Henjum et al. 1994, p. 6; McIntosh et al. 1994, p. 37; Wissmar et al. 1994, p. 28; MBTSG 1995a, p. i; MBTSG 1994b, p. i; MBTSG 1995c, p. i; MBTSG 1995d, p. 1; MBTSG 1995e, p. 1; USDA and USDI 1995, p. 8; 1997, pp. 132–144; Light et al. 1996, p. 6; MBTSG 1996a, p. ii; MBTSG 1996b, p. 1; MBTSG 1996c, p. i;

MBTSG 1996d, p. i; MBTSG 1996e, p. i; MBTSG 1996f, p. 1; MBTSG 1996g, p. 7; MBTSG 1996h, p. 7). Urbanization and residential development may also impact the physical or biological features and require special management considerations or protection. Timber harvest and road building in or close to riparian areas can immediately reduce stream shading and cover, channel stability, and large woody debris recruitment and increase sedimentation and peak stream flows (Chamberlin et al. 1991, p. 180; Ripley et al. 2005, p. 2436). These activities can, in turn, lead to increased stream temperatures, bank erosion, and decreased long-term stream productivity. The effects of road construction and associated maintenance account for a majority of sediment loads to streams in forested areas; in addition, stream crossings also can impede fish passage (Shepard et al. 1984, p. 1; Cederholm and Reid 1987, p. 392; Furniss et al. 1991, p. 301). Sedimentation affects streams by reducing pool depth, altering substrate composition, reducing interstitial space, and causing braiding of channels (Rieman and McIntyre 1993, p. 6), which reduce carrying capacity. Sedimentation negatively affects bull trout embryo survival and juvenile bull trout rearing densities (Shepard et al. 1984, p. 6; Pratt 1992, p. 6). An assessment of the interior Columbia Basin ecosystem revealed that increasing road densities were associated with declines in four nonanadromous salmonid species (bull trout, Yellowstone cutthroat trout (Oncorhyncus clarkii bouvieri), westslope cutthroat trout (O. c. lewisi), and redband trout (O. mykiss spp.)) within the Columbia River basin, likely through a variety of factors associated with roads. Bull trout were less likely to use highly roaded basins for spawning and rearing and, if present in such areas, were likely to be at lower population levels (Quigley and Arbelbide 1997, p. 1183). These activities can directly and immediately threaten the integrity of the essential physical or biological features described in PCEs 1 through 6. Special management considerations or protection that may be needed include the implementation of best management practices specifically designed to reduce these impacts in streams with bull trout, particularly in spawning and rearing habitat. Such best management practices could require measures to ensure that road stream crossings do not impede fish migration or occur in or near spawning/rearing areas, or increase road surface drainage into streams. Agricultural practices and associated activities adjacent to streams and in upland portions of watersheds also can affect the physical or biological features essential to bull trout conservation. Irrigation withdrawals, including diversions, can dewater spawning and rearing streams, impede fish passage and migration, and cause entrainment. Discharging pollutants such as nutrients, agricultural chemicals, animal waste, and sediment into spawning and rearing waters is also detrimental (Spence et al. 1996, p. 128). Agricultural practices regularly include stream channelization and diking, large woody debris and riparian vegetation removal, and bank armoring (Spence et al. 1996, p. 127). Improper livestock grazing can promote streambank erosion and sedimentation and limit the growth of riparian vegetation important for temperature control, streambank stability, fish cover, and detrital input (Platts 1991, pp. 397–399). In addition, grazing often results in increased organic nutrient input in streams (Platts 1991, p. 423). These activities can directly and immediately threaten the integrity of the essential physical or biological features described in PCEs 1 through 8. Special management could include best management practices specifically designed to reduce these types of impacts in streams with bull trout, such as fencing livestock from stream sides, moving animal feeding operations away from surface waters, using riparian buffer strips near crop fields, minimizing water withdrawal from streams, avoiding stream channel and spring head alteration, and avoiding stream dewatering. Dams constructed without fish passage or with poorly designed fish passage features create barriers to migratory bull trout, precluding access to suitable spawning, rearing, and migration habitats. Dams disrupt the connectivity within and between watersheds essential for maintaining aquatic ecosystem function (Naiman et al. 1992, p. 127; Spence et al. 1996, p. 141) and bull trout subpopulation interaction (Rieman and McIntyre

1993, p. 15). Natural recolonization of historically occupied sites can be precluded by migration barriers (e.g., McCloud Dam in California, or impassable culverts under roads). Also, fluctuation of reservoir levels may affect bull trout populations, although these effects are best determined on a casespecific basis. These activities can directly and immediately threaten the integrity of the essential physical or biological features described in PCEs 2 through 7 and 9. Special management considerations that may be needed include the implementation of best management practices, such as providing fish passage, specifically designed to reduce these impacts in streams with bull trout. Mining can degrade aquatic systems by generating sediment and heavy metals pollution, altering water pH levels, and changing stream channels and flow (Martin and Platts 1981, p. 2). These activities can directly and immediately threaten the integrity of the essential physical or biological features described in PCEs 1, 6, 7, and 8, even if they occur some distance upstream from critical habitat. Special management could require best management practices specifically designed to reduce these impacts in streams with bull trout, such as avoiding surface water impacts from mining activities and neutralizing toxic materials. Introductions of nonnative invasive species by the Federal government, State fish and game departments, and unauthorized private parties across the range of bull trout have resulted in predation, declines in abundance, local extirpations, and hybridization of bull trout (Bond 1992, p. 3; Howell and Buchanan 1992, p. viii; Donald and Alger 1993, p. 245; Leary et al. 1993, p. 857; Pratt and Huston 1993, p. 75; MBTSG 1995b, p. 10; MBTSG 1995d, p. 21; Platts et al. 1995, p. 9; MBTSG 1996g, p. 7; Palmisano and Kaczynski, in litt.1997, p. 29). Nonnative species may exacerbate stresses on bull trout from habitat degradation, fragmentation, isolation, and species interactions (Rieman and McIntyre 1993, p. 3). These activities can over time directly threaten the integrity of the essential physical or biological features described in PCE 9. Special management needs and considerations could require the implementation of best management practices specifically designed to reduce these impacts in streams with bull trout, such as avoiding future introductions, eradicating or controlling introduced species, and managing habitat to favor bull trout over other species. Urbanization and residential development in watersheds has led to decreased habitat complexity (uniform stream channels and simple nonfunctional riparian areas); impediments and blockages to fish passage; increased surface runoff (more frequent and severe flooding); and decreased water quality and quantity (Spence et al. 1996, pp. 130–134). In nearshore marine areas, urbanization and residential development has led to significant loss or physical alteration of intertidal and shoreline habitats, as well as to the contamination of many estuarine and nearshore areas (PSWQAT 2000, p. 47; BMSL et al. 2001, ch. 10, pp. 1–27 ; Fresh et al. 2004, p. 1). Activities associated with urbanization and residential development can incrementally threaten the integrity of the essential physical or biological features described in PCEs 1 through 5, 7, and 8. Special management could require best management practices specifically designed to reduce these impacts in streams with bull trout, such as setting back developments from riparian areas; minimizing water runoff from urban areas directly to streams; minimizing hard surfaces such as pavement; and minimizing impacts related to fertilizer application.

Life History

Feeding Narrative

Adult: Resident and juvenile bull trout prey on invertebrates and small fish. Adult migratory bull trout primarily eat fish. Food is taken as opportunities are presented; resources are widespread and readily available.

Reproduction Narrative

Adult: Stream-resident bull trout spawn in the same tributary streams where they complete their life cycle. Migratory bull trout spawn in tributary streams during the fall (75 FR 63929).

Geographic or Habitat Restraints or Barriers

Adult: No information available.

Spatial Arrangements of the Population

Adult: Room for growth (individual and population), food; water; minerals/nutrients; cover or shelter; breeding, reproduction, and rearing sites; and protected habitats (75 FR 63929).

Environmental Specificity

Adult: No information available.

Tolerance Ranges/Thresholds

Adult: Bull trout need cold water to survive, and are seldom found in waters where temperatures exceed 15° to 18° C (59° to 64° F) (USFWS 2015a).

Site Fidelity

Adult: High degree of site fidelity (USFWS 2008).

Dependency on Other Individuals or Species for Habitat

Adult: No information available.

Habitat Narrative

Adult: Bull trout live in cold water below 20 °C (65° F) and require freshwater with gravel for spawning. Migratory bull trout depend on stable streams and unblocked migratory corridors.

Dispersal/Migration

Motility/Mobility

Adult: There are two forms of bull trout: one resident (nonmigratory) and one migratory. The migratory form travels from spawning and nonspawning habitats; any resident-only forms found today may often reflect a loss of the migratory component due to impacts such as habitat loss or migration barriers (75 FR 63898).

Migratory vs Non-migratory vs Seasonal Movements

Adult: Migratory bull trout spawn in the late summer to early fall in smaller streams; and after one to four years of growth they move to larger bodies of water for the winter, coming back to the spawning areas in spring. Nonmigratory bull trout stay in the same stream or creek for their entire lives. (UC Davis 2014).

Dispersal

Adult: Historically, most bull trout populations may have included a migratory component, and any resident-only forms found today may often reflect a loss of the migratory component due to impacts such as habitat loss or migration barriers (75 FR 63898).

Immigration/Emigration

Adult: No information available.

Dependency on Other Individuals or Species for Dispersal

Adult: No information available.

Dispersal/Migration Narrative

Adult: Migratory bull trout spawn in the late summer to early fall in smaller streams. They move to larger bodies of water during the winter, and return to the spawning areas in spring. Resident bull trout stay in the same stream or creek for their entire lives.

Additional Life History Information

Adult: No information available.

Population Information and Trends

Population Trends:

Short-Term Trend: neither increasing nor decreasing (USFWS 2008).

Species Trends:

Long-Term Trend: declining (NatureServe 2015).

Population Growth Rate:

No information available.

Number of Populations:

81 to 300 (NatureServe 2015).

Population Size:

100,000 to less than 1,000,000 (NatureServe 2015).

Minimum Viable Population Size:

5,000 individuals; some habitats support far smaller populations (75 FR 63933).

Resistance to Disease:

No information available.

Adaptability:

High (USFWS 2008)

Additional Population-level Information:

None.

Population Narrative:

Bull trout, at both species and population level, are declining. There are currently 81 to 300 populations, and anywhere from 100,000 to less than 1,000,000 individuals. There is little known information regarding population numbers or whether any Distinct Population Segments are stable.

Threats and Stressors

Stressor: Habitat degradation and fragmentation
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Degraded conditions have severely reduced or eliminated migratory bull trout as water temperature, stream flow, and other water quality parameters fall below the range of conditions that these fish can tolerate.

Stressor: Pollution
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Pollutants can generate sediment, change levels of heavy metals, and alter the pH levels of the water (75 FR 63930).

Stressor: Introduction of nonnative species
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Brook trout, introduced throughout much of the range of bull trout, easily hybridize with them, producing sterile offspring. Brook trout also reproduce earlier and at a higher rate than bull trout, so bull trout populations are often supplanted by these nonnatives.

Stressor: Blockage of migratory corridors
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Dams and other in-stream structures affect bull trout by blocking migration routes, altering water temperatures, and causing loss of fish as they pass through and over dams or are trapped in irrigation and other diversion structures.

Stressor: Warm water temperatures
Exposure: See narrative.
Response: See narrative.
Consequence: See narrative.
Narrative: Due to climate change, water temperatures are rising. Because bull trout require cold waters, their movements to spawning, overwintering, rearing, and foraging habitats may be restricted (75 FR 63932).

Stressor: Habitat Threats
Exposure:
Response:
Consequence:
Narrative: Coastal Recovery Unit: Habitat Threats Puget Sound Region All core areas containing the anadromous bull trout life history form are reliant on access to marine and estuarine FMO habitats (Goetz et al. 2004; Hayes et al. 2011), so restoration of impaired and protection of functioning estuarine and nearshore marine habitats is considered a critical component of bull

trout recovery in this region. Although specific studies examining the impacts of this degradation to bull trout are lacking, nearshore ecosystem impacts, impacts to salmonids in general, and impacts to bull trout prey species are clear. This degradation significantly impacts habitats not only required by anadromous bull trout, but also their key prey species (e.g., juvenile salmon, surf smelt, sandlance, herring) (Shipman et al. 2010; Fresh et al. 2011). In 2000, it was estimated that one third of Puget Sound's shoreline had been modified, with over half of the main basin of Puget Sound having been altered (PSWQAT 2000). Although efforts to remove armoring have since been implemented, overall shoreline armoring continues to increase in Puget Sound (PSP 2013). Nearly 100 percent of the Duwamish estuary and Elliott Bay shoreline has been modified by some type of armoring (BMSL et al. 2001). Over 98 percent of the historic intertidal and subtidal habitat in Commencement Bay is reported to have been lost (WSCC 1999). In areas where nearshore habitats currently remain intact or only partially modified, development continues to threaten these habitats (PSP 2013). Specific recovery actions in the Puget Sound region may include removing or modifying artificial structures such as bulkheads, riprap, dikes, and tide gates; restoring tidal flow to coastal wetlands; contaminant remediation; or restoring eelgrass beds, kelp beds, and other nearshore habitats or processes. Throughout Puget Sound, development and related impacts (e.g., flood control, flood plain disconnection, bank armoring, channel straightening, loss of instream habitat complexity) along mainstem river corridors are common. Some of the most complex and costly restoration actions will be required to restore more natural features and functions to these areas. Although the impacts of agriculture, residential development, and urbanization are not currently believed to pose a primary threat to migratory bull trout using the lower Chilliwack River and lower A-10 Fraser River, conservation actions that address these activities should continue to be implemented in these areas as these river reaches are key migration corridors for the continued expression of the anadromous life history form. Several core areas continue to be impacted by past forest management practices (harvest and roads). Since the time of listing, these impacts have and are anticipated to continue to decline as new forest management practices and restoration actions are implemented. One core area (Chester Morse Lake) in this region has no primary habitat threats to bull trout (USFWS, 2015a).

Recovery

Delisting Criteria:
For the Coastal, Mid-Columbia, and Upper Snake Recovery Units, primary threats are effectively managed in at least 75 percent of all core areas, representing 75 percent or more of bull trout local populations within each of these four recovery units (USFWS, 2015).

For the Columbia Headwaters Recovery Unit, primary threats are effectively managed in at least 75 percent of all complex core areas, representing 75 percent or more of bull trout local populations in complex core areas within this recovery unit; and at least 75 percent of simple core areas within this recovery unit (USFWS, 2015).

For the Klamath and Saint Mary Recovery Units, all primary threats are effectively managed in all existing core areas, representing all existing local populations. In addition, because nine of the 17 known local populations in the Klamath Recovery Unit have been extirpated and others are significantly imperiled and require active management, it is believed that the geographic distribution of bull trout within this recovery unit needs to be substantially expanded before it can be considered to have met recovery goals. To achieve recovery, seven additional local populations are being sought, distributed among the three core areas (USFWS 2015).

For core areas to meet the criterion, in recovery units where shared foraging, migration, and overwintering (FMO) habitat outside core areas has been identified (Appendix G), connectivity and habitat in shared FMO areas should be maintained in a condition suitable for regular bull trout use and successful dispersal among the connecting core areas. Shared FMO areas that function suitably to meet the criterion should provide the primary constituent elements of critical habitat specific to migration habitat (USFWS, 2015).

Recovery Actions:

- Conserve bull trout populations to ensure that they are demographically stable in all six of the bull trout recovery units (80 FR 31917).
- Manage all six recovery units to remediate threats and ensure that the bull trout are unlikely to become endangered (80 FR 31917).
- Grow bull trout conservation efforts and better understand the effects of various threats on bull trout (80 FR 31917).
- Work cooperatively with our partners to design, fund, prioritize, and implement effective conservation actions in those areas that offer the greatest long-term benefit to sustain bull trout, and where recovery can be achieved (80 FR 31917).
- Apply adaptive management principles to the implementation of the bull trout recovery program, to account for new information (80 FR 31917).
- Recommendations for Future Actions: The final recovery plan was published on September 30, 2015. The ultimate goal of the recovery plan is to manage threats and ensure sufficient distribution and abundance to improve the status of bull trout throughout their extant range in the coterminous United States (listed entity) so that protection under the Endangered Species Act (Act) is no longer necessary. When this is achieved, we expect that: • Bull trout will be geographically widespread across representative habitats and demographically stable in each recovery unit; • The genetic diversity and diverse life history forms of bull trout will be conserved to the maximum extent possible; and • Cold water habitats essential to bull trout will be conserved and connected. To achieve these goals the final recovery plan and RUIPs outline actions necessary to: • Effectively manage and ameliorate primary threats. • Work cooperatively with partners to implement buH trout recovery actions. • Adaptively manage the bull trout recovery program (USFWS, 2014).
- Two perpetual conservation covenants: one on lands controlled by PacifiCorp utilities, in the Cougar/Panamaker Creek area; and another on PacifiCorp's and Cowlitz County Public Utility District's lands along the Swift Creek arm of Swift Creek Reservoir (75 FR 63958).
- Upstream and downstream fish passage improvements at all reservoirs (75 FR 63958).
- Increase flows and salmon spawning enhancements in the bypass reach (75 FR 63958).
- Complete a limiting factor analysis for bull trout to determine additional enhancement measures (75 FR 63959).
- Establish a public information program to protect bull trout (75 FR 63959).
- Monitor and evaluate efforts for bull trout conservation measures (75 FR 63959).
- Coastal Recovery Unit: Conservation Recommendations • Promote interagency collaboration and coordination on bull trout recovery actions by supporting existing bull trout working groups or the formation of new bull trout working groups where they do not exist. While working groups may be facilitated by any interested stakeholder, most often they are organized and facilitated by the Service, a State agency, U.S. Forest Service, or a

Tribal entity. Although the Service has no guidelines for format or process, existing working groups are largely informal, are organized at various scales (e.g., core area, river basin, geographic region, or recovery unit) and generally meet at least annually. • Increase information outreach to anglers. Provide information on bull trout identification, special regulations, methods to reduce hooking mortality of bull trout caught incidentally, and the value of bull trout and their habitat. Education and outreach designed to assist anglers in identifying and differentiating captured brook trout from bull trout is needed to reduced unintended take of bull trout. • Conduct a genetic pedigree assessment to assess donor stock life stage contribution. At a future date, conduct a genetic assessment of naturally produced bull trout in the Clackamas River compared against fin clips taken from donor stock to assess which life stages contributed to the naturally produced population and perhaps which life stage was most effective in the reestablishment of bull trout in the Clackamas River. • Replicate the 2009 baseline foodweb investigation. After Phase One of the project is complete (2016), replicate the baseline foodweb investigation that occurred in 2009 to determine the impact of the bull trout reintroduction on the Clackamas River foodweb (Lowery and Beauchamp 2010) (USFWS, 2015a).

- Columbia Headwaters Recovery Unit: Conservation Recommendations 4.1.1 Evaluate current and legacy land and water management effects. Determine how timber management, roads, mining, and increases in peak flow have affected bull trout habitats and identify actions to eliminate negative effects or improve conditions. Utilize the Distributed HydrologySoil-Vegetation Model (DHSVM) to assess management related impacts on stream flows from forest harvest and roads. 4.1.2 Complete watershed assessment. Complete water quality assessments and comprehensive watershed assessments in key watersheds and develop remedies for issues that are identified. Utilize the DHSVM model as part of the watershed assessments in key watersheds. 4.2.1 Research bull trout life history in the St. Joe River. Investigate distribution, status, critical habitat needs and survival during different stages of bull trout life cycle to better guide conservation efforts in the St. Joe River. 4.2.2 Conduct genetic analysis. Conduct genetic analysis to determine the appropriateness of adding genes from other populations to potentially refound bull trout local populations in the Coeur d'Alene River headwaters. 4.2.3 Improve knowledge of distribution. The St. Joe headwaters are a high priority for additional presence/absence survey mapping, potentially using new e-DNA survey techniques. This will better enable restoration projects to target improved connectivity amongst cold water patches and work toward restoring more of the migratory life history form (USFWS, 2015b)
- Klamath Recovery Unit: Ongoing Klamath Recovery Unit Conservation Measures (Summary) In the Upper Klamath Lake core area, suitable habitat for bull trout in Sun Creek and Threemile Creek have expanded by removing nonnative fish (brook trout, bull trout × brook trout hybrids, and brown trout [Sun Creek only]) through recent piscicide and electrofishing treatments, and by installing exclusion barriers to prevent re-invasion by nonnatives (Buktenica et al. 2013; USFWS unpublished data). Within Threemile Creek, future recovery actions include adding large woody debris to increase pool habitat, channel restoration, and channel enhancement in downstream reaches for improved connectivity. Within Sun Creek, future conservation work includes reconnecting Sun Creek to the Wood River, which will allow full connectivity to FMO habitat (mainstem Wood River and Agency Lake) and to additional spawning and rearing habitat. In addition to these two streams, ongoing conservation actions within the core area include acquiring water rights for additional instream flow, replacing diversion structures, installing fish screens, constructing bypass channels, and installing riparian fencing. The ongoing conservations actions have been

conducted by or are being undertaken by multiple entities, including Crater Lake National Park, Oregon Department of Forestry, Oregon Department of Fish and Wildlife, The Klamath Tribes, Fremont-Winema National Forest, Klamath Basin Rangeland Trust, the U.S. Fish and Wildlife Service, and private landowners. In the Sycan River core area, recent changes in land management have begun restoring historic forest structure, species composition and function to reduce the risk of catastrophic wildfire. Removal of water control structures in Sycan Marsh has restored the historic hydrologic regime. Eliminating these structures will allow streams to access their floodplains, which may potentially buffer the impacts of projected changes in future stream flow. Additional restoration activities include increasing riparian vegetation to reduce channel width and improve instream habitat conditions, and restoring hardwoods in riparian areas to provide microhabitats that reduce the effects of irradiance (Lawler et al. 2010; Wong and Bienz 2011). Barrier removal has established connectivity from Long Creek to Upper Klamath Lake. Culvert barriers have been replaced in Coyote Creek and in tributaries to the upper Sycan River. Brook trout control efforts in Long Creek have been ongoing, but have not yet been shown to be effective. A structured decision making approach (Conroy and Peterson 2012) was recently initiated to provide management direction. The goal of the process is to achieve long-term viability of bull trout populations in the Sycan River core area through expanding and maintaining existing populations, establishing new populations, and improving stream and riparian habitats. Additional ongoing recovery actions within the Sycan River core area include Sycan River realignment within the Sycan Marsh. Achieving realignment will reconnect the Sycan River to Long Creek, which will open 60 miles of Sycan River and tributary habitat to bull trout. Cooperators in recovery actions include The Nature Conservancy, Fremont-Winema National Forest, Oregon Department of Fish and Wildlife, The Klamath Tribes, Green Diamond Resource Company, U.S. Geological Survey, and the U.S. Fish and Wildlife Service. In the Upper Sprague core area, bull trout habitat restoration efforts have included culvert replacements, removals, or modifications in multiple streams to provide the opportunity for bull trout to express migratory behavior, allow for genetic exchange, and increase resiliency to potential catastrophic events, such as wildfire. Bull trout within Leonard and Brownsworth creeks now have full volitional access to the entire drainage network. Additionally, large woody debris has been added to these two creeks to improve instream habitat. Within Boulder Creek, one barrier culvert has been replaced and the last culvert is scheduled to be replaced, which will provide access to the entire stream system. Within Deming Creek, culvert replacement has occurred and plans are in place to replace and/or modify additional culverts to improve fish passage. Habitat restoration efforts for Deming Creek have been initiated or is ongoing and includes riparian fencing, adding large woody debris, riparian plantings, and improved grazing management. Future plans are in place for reconnecting Deming Creek to the South Fork Sprague River. Additional ongoing conservation actions include large woody debris additions to the South Fork Sprague River and installing a fish screen on the North Fork Sprague River to prevent entrainment. Cooperators in recovery actions include the Fremont-Winema National Forest, Oregon Department of Fish and Wildlife, The Klamath Tribes, Klamath Basin Rangeland Trust, Green Diamond Resource Company, Deming Ranch Land and Cattle, the Service, and private landowners (USFWS, 2015c).

- Mid-Columbia Recovery Unit: Ongoing Mid-Columbia Recovery Unit Conservation Measures (Summary) In the John Day River basin of Oregon, the U.S. Forest Service, Bureau of Reclamation, and BLM are working with private landowners and the Confederated Tribes of the Warm Springs on projects for road removal, channel restoration, mine reclamation, improved grazing management, removal of passage barriers, reductions in Forest road network impacts, and restoration of floodplains impacted by legacy dredge mining, all of which are actions that will benefit bull trout in all three core areas (North Fork, Middle Fork, and Upper Mainstem John Day core areas). In the Asotin, Tucannon, Walla Walla, Touchet, Yakima, Wenatchee, Entiat, and Methow core areas in Washington, considerable progress has been made in eliminating fish passage barriers, reducing impacts at PUD mainstem Columbia River dams, improving riparian habitat conditions, and restoring salmon runs. Across the national forest most of the large culverts in spawning and rearing habitat have been replaced with wider, larger, open bottom arch culverts or bridges. In the Touchet River, Walla Walla River, and Mill Creek several projects screening irrigation ditches, consolidating ditches, and modifying diversion structures have been completed. In the Tucannon and Touchet rivers, the Tri-State Steelheaders, WDFW, and the Snake River Salmon Recovery Group have implemented many projects increasing wood, improving complexity, and reconnecting floodplains through levee removal or set-backs. A major fish ladder installed at Nursery Bridge near Milton Freewater facilitates passage of large salmon, steelhead, and bull trout. A settlement agreement signed by three local irrigation districts and the Service provides for maintenance of instream flows in a stretch of the Walla Walla River that had been seasonally dewatered by irrigation diversions. Additional actions that have been occurring in these core areas include restoration of stream habitat complexity, extensive road decommissioning, removal of levees, and changes in agricultural water use. In the Clearwater River basin in Idaho, a variety of stream restoration projects have been implemented on Federal lands (Nez Perce-Clearwater National Forests, Bureau of Land Management) to benefit bull trout within the South Fork Clearwater River, North Fork Clearwater River, and Lochsa River core areas. For example, the Nez Perce Tribe has funded fish habitat restoration in the Lochsa River Core Area, in conjunction with a Forest Service land exchange with Western Pacific Timber properties. Additionally, the Forest Service and BLM have actively pursued restoration activities in the South Fork Clearwater River Core Area including the removal of culvert barriers on many tributaries (e.g., East Fork American River) and habitat restoration (e.g., Crooked River) through the placement of large woody debris, boulders, and other structures as well as riparian restoration (USFWS 2008a). In the Yakima, Wenatchee, Entiat, Methow, and mainstem Columbia areas many actions have been implemented or are ongoing and involve continued monitoring in association with some of the large scale actions listed below. Culverts have been replaced on major salmon and bull trout spawning areas some by bridges (i.e., Deep Creek in the Yakima). U.S. Forest Service grazing allotments in areas of spawning have included ongoing management plans with the help of permitees to reduce trampling of redds, sedimentation, improve riparian areas, etc. (i.e., Twisp, Beaver, Goat in the Methow; Tributaries in the Mad and Entiat Rivers; and Teanaway, South Fork Tieton, Naches basins in the Yakima). The Department of Natural Resources continues to monitor grazing in Ahtanum Creek in association with resource conservation plans in spawning areas. Fishing regulation and fish stocking has been further changed since listing to reduce impact on some populations of bull trout and future monitoring efforts will serve to improve them further. Fish irrigation diversions and instream flows in the Methow have incrementally improved since listing. Hydrologic permit approvals from WDFW continue to improve and assist work in the channel associated with construction or development. Fish screening criteria has been improved in most basins and incurs ongoing maintenance. Ongoing bull trout conservation is occurring because of the Grant, Chelan, and Douglas County Public Utility Districts (PUDs) Federal Energy Regulatory Commission (FERC) relicensing biological opinion, settlement agreements, and bull trout management plans for the continued operation and maintenance of PUD operated Columbia River dams and associated activities, the PUD Habitat Conservation Plans and Tributary funds projects, and the implementation of the biological opinion for the Leavenworth National Fish Hatchery. Future conservation is expected to occur through section 7 consultation under the Act with BOR for the Yakima Irrigation Ongoing Operations and Maintenance Project. In addition, the Yakima Basin Bull Trout Action Plan and upper Columbia salmon recovery planning documents list many other actions that have been implemented in foraging, migration, and overwintering areas that will improve conditions for bull trout (i.e., fish screens and passage features for anadromous species at Yakima, Naches, Toppenish, and Ahtanum diversions in FMO habitat). Other large scale ongoing actions that are implemented as a result of terms and conditions from a section 7 Biological Opinion, or are specifically designed for recovery of bull trout or other salmonids, can benefit bull trout. The Idaho Department of Lands along with other nonFederal forest land managers have implemented modern forest practices that have contributed to improved bull trout habitat conditions and distribution. Since at least 1986, under the Idaho Forest Practices Act and the Stream Channel Protection Act, all stream crossings on fish bearing streams must provide for fish passage. The Idaho Forest Practices Act, Title 38, Chapter 13, Idaho Code, pertaining to road construction, reconstruction, and maintenance (Rule 040) states: Culvert installations on fish bearing streams must provide for fish passage. Specific guidelines are found in the Rules Pertaining to Stream Channel Alteration, Title 37, Chapter 03, Idaho Code. Idaho Department of Lands actively replaces fish barriers and over the last 10 years has replaced 91 fish blocking culverts with fish passable structures in the Mid-Columbia Recovery Unit. Other ongoing actions span across multiple recovery units and include implementation of the Northwest Forest Plan, Pacific Anadromous Fish Strategy/Inland Fish Strategy (PACFISH/INFISH) and associated Aquatic Conservation Strategy objectives, consultations on EPA's approval of State temperature standards, various habitat conservation plans and associated biological opinions, and the Federal Columbia River Power System (FCRPS) biological opinion and ongoing work with Federal power operators to minimize impacts to bull trout. In addition, significant recovery actions are being implemented across the Mid-Columbia Recovery Unit for salmon and steelhead with direct benefits to bull trout (e.g., habitat restoration, fish passage, etc.). Bull trout in many Washington core areas have also benefited from improved forestry management reducing impacts on aquatic and riparian systems, resulting from implementation of the 2006 Washington State Forest Practices HCP with the Washington Department of Natural Resources (USFWS, 2015d).

- St. Mary Recovery Unit: Ongoing Saint Mary Recovery Unit Conservation Measures The primary issue precluding bull trout recovery and eventual delisting in the Saint Mary Recovery Unit relates to biological impacts of water diversions, specifically those documented as attributable to the BOR Milk River Project. This includes dewatering of Swiftcurrent Creek and the Saint Mary River channel, entrainment of bull trout at the Saint Mary Diversion Dam, and at least seasonal migration barriers to upstream bull trout movement at the diversion. The Service is currently engaged with BOR in informal consultation under section 7 of the Endangered Species Act to facilitate rehabilitation and necessary corrective actions at the Saint Mary Diversion Dam. The Blackfeet Nation Bull Trout Management Plan was adopted in 2010 (Skunk Cap et al. 2010). This document, adopted by the Blackfeet Tribal Business Council, certifies that the Blackfeet Tribe, in cooperation with Federal, State, and local government agencies, will work to complete the recovery measures outlined in the 2002 Draft Recovery Plan (USFWS 2002), within such funding constraints as resources are made available to the Tribe. The Tribe has the necessary regulatory authority and ordinances in place to protect and conserve bull trout and their habitat (USFWS, 2015e).

- Upper Snake Recovery Unit: Ongoing Upper Snake Recovery Unit Conservation Measures (Summary) Since the listing of bull trout, numerous conservation measures have been and continue to be implemented within the Upper Snake Recovery Unit. These measures are being undertaken by a wide variety of local and regional partnerships, including State fish and game agencies, State and Federal land management and water resource agencies, Tribal governments, power companies, watershed working groups, water users, ranchers, and landowners. In many cases, these bull trout conservation measures incorporate or are closely interrelated with work being done for recovery of salmon and steelhead, which are limited by many of the same threats. Many restoration projects have been implemented from local funds as well as Bonneville Power Administration funds in predominantly anadromous drainages. Bonneville Power Administration has also funded projects in the Malheur River to support Tribal efforts in recovering bull trout. The Bureau of Reclamation has been implementing various projects within the Malheur and Boise watersheds to better understand the impacts of their operations on bull trout populations. The numerous localized fish habitat restoration projects in the Salmon River basin that are implemented by Federal, State, and private partners (U.S. Forest Service, Bureau of Land Management, Upper Salmon Basin Watershed Program) should continue and be expanded if possible, to protect and maintain the currently robust population. The Upper Salmon Basin Watershed Program has implemented over 500 projects since 1993 to increase instream flow and improve fish habitat across the Salmon River headwaters, Lemhi River, and Pahsimeroi River watersheds. The program, coordinated by the Idaho Governor’s Office of Species Conservation, works with cooperating private landowners to develop restoration projects and obtain funding from Bonneville Power Administration and other agencies. Projects have included removal of migration barriers to provide fish access to 75 miles (121 kilometers [km]) of stream, screening of 249 irrigation diversions, instream habitat improvement in 494 miles (795 km) of stream, and riparian habitat restoration over 352 miles (566 km) of stream (158 miles [254 km] fenced). Projects have benefited bull trout, salmon, and other salmonid species. The Forest Service and Bureau of Land Management have updated their Land and Resource Management Plans (LRMPs) and Resource Management Plans to incorporate conservation measures that protect both local populations and habitat used by bull trout. Some Forests did not revise their LRMPs but amended them to include fish and riparian conservation strategies to protect inland native fish and anadromous fish habitat. Numerous passage projects have also increased the amount of habitat as well as improved connectivity throughout the recovery unit. Both these Federal agencies have areas within the Upper Snake with special designations such as Wild and Scenic River (Jarbidge River, Malheur River) or Wilderness Designation (Frank Church Wilderness of No Return in the Salmon River and the Jarbidge Wilderness in the Jarbidge River). Both of these designations afford protection for bull trout and its habitat. Another designation that provides protection at a smaller scale are Wilderness Study areas that are dispersed throughout the Upper Snake with concentrations in southeast Oregon and central Idaho. In southwestern Idaho, the U.S. Forest Service, Idaho Department of Fish and Game, and cooperating private landowners should continue to implement upland and stream habitat restoration actions. Fish passage barriers within the following core areas (e.g., Arrowrock, Squaw Creek, North Fork Payette, and Deadwood core areas) should be evaluated and addressed to improve bull trout population connectivity. The Idaho Department of Lands (IDL) also implements conservation measures, particularly replacing fish barriers with road crossings that pass fish, on fish bearing streams and at crossings where fish presence is unknown but fish habitat is present. These projects are generally accomplished in conjunction with IDL's timber sale program where timber sale purchasers are given a development credit for this work.

Additional Threshold Information:

- No information available.
- No information available.

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Not applicable.

SPECIES ACCOUNT: *Satan eurystomus* (Widemouth blindcat)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered

Physical Description

A thorough understanding of the morphological variability of the toothless and widemouth blindcats is constrained by the few specimens collected and deposited in museum collections. Like other ictalurid species, blindcats lack scales and possess eight barbels (i.e., whisker-like sensory organs) arranged around the snout and mouth (Figures 1 and 2; Eigenmann 1919, p. 398; Hubbs and Bailey 1947, pp. 5, 10; Lundberg 1982, p. 16; Burr et al. 2020, p. 42). The toothless and widemouth blindcats appear to be among the smallest known ictalurids, reaching total lengths of up to 103.8 millimeters (mm) [4.1 inches (in)] and 136.9 mm (5.4 in), respectively (Hubbs and Bailey 1947, pp. 8–10, 12–14; Suttkus 1961, pp. 62–63; Lundberg 1982, pp. 10–11; Langecker and Longley 1993, p. 977; Burr et al. 2020, p. 26). Average size of collected toothless blindcats is 81. 2 mm (3.2 in) and 105 mm (4.1 in) for widemouth blindcats (Longley and Karnei 1978a, p. 43; 1978b, pp. 46, 49). A large toothless blindcat specimen (i.e., 87 mm [3.4 in]) weighed 16 grams (g) [0.6 ounces (oz)], with a large widemouth blindcat weighing 27 g (1.0 oz) [Karnei 1978, p. 79]. Neither species exhibits sexual dimorphism (USFWS, 2022)

Taxonomy

The toothless and widemouth blindcats are members of the catfish (Siluriformes) family Ictaluridae (Arce-H et al. 2017, pp. 406–407). Both species are the only members of their respective genera, Trogloglanis and Satan (Arce-H et al. 2017, pp. 406–407, 415). The toothless blindcat was described by Eigenmann (1919, pp. 397, 399–400) from a single individual collected, sometime prior to 1919, from an artesian well (i.e., George W. Brackenridge Well) in the City of San Antonio, Bexar County, Texas (Zara Environmental 2020, pp. 12, 14). A second specimen of that species was made available to researchers in the late 1930s (Hubbs and Bailey 1947, p. 1). That specimen was reportedly taken in 1934 from another artesian well (i.e., Josef Boecke Well) in or near the City of San Antonio (Hubbs and Bailey 1947, pp. 1–2; Zara Environmental 2020, pp. 12, 14). The toothless blindcat's initial description provided a very limited and general morphological description of the single specimen available at the time (Eigenmann 1919, pp. 399–400). Hubbs and Bailey (1947, pp. 11–14) redescribed the toothless blindcat with a much more robust and detailed assessment of the species' morphology. The widemouth blindcat was described by Hubbs and Bailey (1947, pp. 1, 4–11) from a single individual collected, sometime before 1938, from an artesian well (i.e., William Kempin Well) in the City of San Antonio (Zara Environmental 2020, pp. 12, 14). Examinations of these blindcat's phylogeny are restricted to morphological characters alone at present. Molecular investigations of blindcat genetics are either very limited or unavailable as chemical preservation methods applied in the past inhibit the ability of researchers to obtain usable genetic material (Zara Environmental 2010, pp. 21, 31–32; Lundberg et al. 2017, pp. 118– 119; Arce-H et al. 2017, p. 423; Zara Environmental 2020, p. 3). The most recent and comprehensive phylogenetic assessment of North American ictalurid species found that the toothless and widemouth blindcats, along with the Mexican blindcat (Prietella phreatophila) and Phantom blindcat (P. lundbergi), comprise a distinct clade (i.e., Troglobites) [Arce-H et al. 2017, pp. 415, 417–418, 422–423]. At minimum, the lineage of this clade is estimated to be 30–37 million years old (USFWS, 2022)

Current Range

The toothless and widemouth blindcats are endemic to a portion of the karstic Edwards Aquifer in Bexar County, Texas. An aquifer is a rock unit capable of storing and transmitting water (Ford and Williams 2007, p. 103; White 2012, p. 383). The term "karst" refers to a type of terrain and subsurface structures (e.g., caves and conduits) that are formed by the slow dissolution of calcium carbonate from surface and subsurface limestone, and other soluble rock types (e.g., carbonites and evaporates), by mildly acidic groundwater (Holsinger 1988, p. 148; Culver and Pipan 2009, pp. 5–15). Flow of groundwater through pores and along faults, and fractures leads to the formation of a system of interconnected subterranean conduits that become larger as bedrock is dissolved (Ford and Williams 2007, pp. 103–106, 112–114; Culver and Pipan 2009, pp. 5–8; Veni 2012, pp. 603–608; White 2012, pp. 383–386). Karst aquifers are typified by networks of conduits that can transport water relatively quickly over significant distances underground. All known specimens of the toothless and widemouth blindcats have been collected from groundwater wells along a southwest to northeast trending line through Bexar County, roughly paralleling the southeastern boundary of the aquifer's artesian zone (Figure 6). To date, individuals of the toothless blindcat have been expelled from eight wells and the widemouth blindcat from five wells (Zara Environmental 2020, pp. 11–12; Diaz 2021, p. 30; Diaz et al. 2021, pp. 3; Diaz 2022b). The species co-occur at two wells. Wells that have produced either species tap subsurface Edwards Group Formations (Figure 7), ranging in depth from 308 m (1,010 ft) to 582 m (1,909 ft) (USFWS, 2022).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Food/Nutrient Narrative

<u>Adult: </u>The widemouth blindcat is hypothesized to be a predator that feeds on stygobiont invertebrates and potentially suitably sized toothless blindcats. For both species to persist, we assume the chemolithoautotrophic food web must persist in an undegraded condition (USFWS, 2022).

Reproduction Narrative

<u>Adult: </u>Stygobiont fishes are generally characterized by increased age at first reproduction, lower numbers of reproductively active females, reduced numbers of eggs, slower growth rates, and longer life spans (Poulson 1963, pp. 266, 268, 275; Trajano 1997, p. 367; Trajano 2001, pp. 152–153; Trajano and Bichuette 2007, p. 114; Niemiller and Poulson 2010, pp. 220–227, 232–235; Secutti and Trajano 2021, p. 103). Stygobiont members of the family Amblyopsidae are among the world's most studied subterranean fishes. The northern cavefish (Amblyopsis spelaea), Ozark cavefish (A. rosae), and southern cavefish (Typhlichthys subterraneus) have estimated lifespans of 30–45, 8–12, and 16–24 years of age, respectively (Niemiller and Poulson 2010, p. 226). Long lifespans have also been documented for some stygobiont catfish species (e.g., Ancistrus cryptophthalmus (i.e., 8–10 years), Ituglanis passensis (i.e., >10 years), and Trichomycterus itacarambiensis, [i.e., >10 years]) in Brazil (Trajano 1997, p. 367; Trajano 2001, pp. 151–152; Trajano and Bichuette 2007, p. 114; Secutti and Trajano 2021, p. 103). Female

northern cavefish do not begin to reproduce until about six years of age (Niemiller and Poulson 2010, p. 221). Niemiller and Poulson (2010, pp. 221–222) estimated that a fraction of mature females produced offspring over a decade; 3% of northern cavefish, 13% of Ozark cavefish, and 7% of southern cavefish females. Females of this group produced fewer eggs than surface congeners (Poulson 1963, pp. 266, 268). Eggs of stygobiont amblyopsids are larger and more nutrient-rich, producing larger immatures than surface congeners (Niemiller and Poulson 2010, p. 224). Average clutch sizes of the northern cavefish (i.e., 65 eggs), Ozark cavefish (i.e., 34 eggs), and southern cavefish (i.e., 58 eggs) are generally small (Niemiller and Poulson 2010 pp. 225–226). Amblyopsids, and some stygobiont catfishes, reproduce seasonally in response to periods of increased nutrient availability (e.g., during periods of increased rainfall) [Poulson 1963, pp. 263– 264; Trajano 1991, p. 417; Niemiller and Poulson 2010, p. 221, 230–232; Secutti and Trajano 2021, p. 95]. A caveat to reproductive seasonality is that the best-studied stygobiont fishes are those that inhabit shallow subterranean systems that rely on direct input of nutrients from the surface (Trajano 1991, p. 417; Niemiller and Poulson 2010, pp. 183, 186, 230–232; Bichuette and Trajano 2021, p. 4; Secutti and Trajano 2021, p. 195). Non-seasonal breeding is seen in some stygobiont fish species (i.e., A. cryptophthalmus) (USFWS, 2022)

Habitat Type

Adult: subterranean groundwater

Habitat Narrative

Adult: Toothless and widemouth blindcats have never been directly observed in their natural subterranean habitat. The spatial configuration (i.e., height, length, and width) of preferred water-filled void space is not known. In general, physical space(s) used by these species likely consists of water-filled caves, fissures, fractures, and other voids of varying diameters (i.e., large enough to allow passage of juveniles and adults). The blindcats are anomalies among stygobiont fishes in terms of the great depths these fishes inhabit in groundwater-saturated strata (Trajano 2001, p. 140; Fišer et al. 2014, p. 976). Therefore, using other fishes as surrogates to ascribe physical habitat needs for the blindcats is tenuous at best. Most described stygobiont fish species have been recorded from shallower subterranean systems (e.g., humanly-accessible water-filled or flooded caves and underground streams) with more direct and immediate connections (e.g., cave entrance) to the surface (Noltie and Wicks 2001, pp. 177, 185–188; Romero and Paulson 2001, pp. 16–33; Trajano 2001, pp. 138–140; Romero et al. 2009, pp. 217–265). This includes Mexican and Phantom blindcats which primarily inhabit caves with surface entrances (Hendrickson et al. 2001, pp. 318–326). Those few stygobiont fishes (Monopterus roseni, Phreatichthys andruzzi, and Stygichthys lyphlops) known only from machine or hand-dug wells have also been taken from much shallower depths (e.g., < 30 m [< 98ft]) than blindcats (Romero and Paulson 2001, pp. 17–18, 23; Trajano 2001, p. 140; Fernández and de Pinna 2005, p. 105; Muriel-Cunha and de Pinna 2005, pp. 334–335; Shibatta et al. 2007, pp. 192–195; Fernández et al. 2007, pp. 53–56). The rock layers that comprise the Edwards Aquifer are extensively honey-combed and cavernous as a result of dissolution by groundwater (Livingston et al. 1936, pp. 72–73; Petitt and George 1956, p. 16; Maclay and Small 1986, p. 61). Faults, fissures, and fractures provide preferential flow paths for groundwater movement which facilitates the enlargement of those features, resulting in the development of interconnected solution channels (i.e., elongated voids in solid rock) and conduits (Livingston et al. 1936, pp. 72–73; Petitt and George 1956, p. 16; Lindgren et al. 2004, pp. 15, 21). Cavernous openings in deeper portions of the Edwards Aquifer have been observed during well-drilling activities. Borehole televiewers have provided images of cavernous openings and solutionally enlarged fractures (Hovorka et al. 2004, p. 8; Lindgren et al. 2004, p. 16). Such void space would likely provide the physical space required or used by toothless and widemouth blindcats (USFWS, 2022).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Subterranean dispersal corridors likely also exist for species inhabiting the karstic Edwards Aquifer. The Texas blind salamander (Eurycea rathbuni) is a federally endangered stygobiont salamander (32 FR 4001) known only from caves, springs, and wells in the Edwards Aquifer of southeastern Hays County, Texas. Dye-tracing has revealed that sites inhabited by that salamander are well-connected by groundwater flow paths (Johnson et al. 2012, pp. 8–10, 73– 79). Preliminary evaluation of Texas blind salamander genetic population structure suggests that sampled localities for this species are not reproductively isolated and interbreed (Chippindale 2009, pp. 8–9; Corbin 2020, p. 75). Though that salamander occupies a structurally different portion of the aquifer, the supposition that populations of aquatic stygobionts (i.e., invertebrates and vertebrates) can be interconnected is supported by research on other taxa (USFWS, 2022).

Population Information and Trends

Population Narrative:

No direct information is available on toothless and widemouth blindcat abundances or population sizes as their habitat is inaccessible to direct human sampling (e.g., mark-recapture or visual censuses). Even in accessible subterranean system, estimating population sizes of stygobiont fishes is notoriously difficult as some portion of their population(s) and/or habitat(s) is often unreachable by surveyors due to cave passage restrictions (Niemiller et al. 2013, p. 1,805; Trajano 2001, pp. 134–136). In humanly-accessible portions of caves, small population sizes have been recorded for the northern cavefish (e.g., 105 individuals; Poulson 1963, p. 269), Ozark cavefish (e.g., 100–200 individuals; Graening et al. 2010, p. 58), and southern cavefish (e.g., 41 individuals; Poulson 1963, p. 269). A survey of the Mexican blindcat found less than 100 individuals in humanly-accessible cave passages (Trajano 2001, p. 145). Population estimates have been developed for some stygobiont catfishes in shallow subterranean systems (e.g., cave streams) of Brazil (Table 5). These estimates suggest that populations of stygobiont catfishes can be large given sufficient physical habitat and food resources (Trajano 2001, pp. 141–142, 144–145; Bichuette and Trajano 2021, p. 10). Longley and Karnei (1978a, pp. 35–36; 1978b, pp. 36, 38–40) extrapolated their well survey data for the toothless and widemouth blindcats to calculate numbers of individuals ejected from wells in terms of well flow rates (i.e., catch per unit effort). For both species, those researchers assumed that fish were randomly exposed to capture by sampled wells and not clumped due to rate of water flow from those wells (Longley and Karnei 1978a, p. 35; 1978b, pp. 36, 38). For the Artesia Pump Station Well (Table 6), average flow at that well, over a 68-day sampling period in 1977, was 21,000 meters3 per day (m3 /day) [17 acre-feet (ac-ft)] with 22 specimens collected (Longley and Karnei 1978b, pp. 38, 54). Over that period, one toothless blindcat was ejected from the well with every 65,000 m3 (53 ac-ft) of water or one fish every 3.1 days (Longley and Karnei 1978b, p. 38). # sampling days/# specimens collected x average daily groundwater flow = catch per unit effort 68 days/22 specimens x 21,000 m3 /day (17 acre-feet (ac-ft) = 1 specimen per 65,000 m3 (53 ac-ft) At that flow rate, Longley and Karnei (1978b, p. 38) extrapolated that 118 toothless blindcats would be expelled from the Artesia Pump Station over 12 months of operation. Based on pumped flow records from 1950 to 1977, potential loss of toothless blindcats from this well was estimated at 3,256 individuals over that 28-year period (Longley and Karnei 1978b, p. 39). Similar estimations were developed for the widemouth blindcat at the Artesia Pump Station Well (Longley and Karnei 1978a, pp. 34–36). At the same flow rate of 21,000 m3 /day (17 ac-ft/day), with 11 specimens collected over 68 days, one widemouth blindcat was estimated to exit the well with every 129,515 m3 (105 ac-ft) of water or one fish every 6.2 days (Longley and Karnei 1978a, pp. 35, 48). Over 12 months, 59 widemouth blindcats would be ejected from the well (Longley and Karnei 1978a, p. 35). From 1950 to 1977, 1,628 widemouth blindcats would potentially have been expelled (Longley and Karnei 1978a, p. 36) (USFWS, 2022).

Threats and Stressors

Stressor: Mortality from Groundwater Wells
Exposure:
Response:
Consequence:
Narrative: As discussed in Section 6.0 Population and Species Needs, it is plausible that populations of the toothless and widemouth blindcats historically numbered in the tens of thousands of individuals. Prior to the advent of groundwater pumping, these fishes were only subject to demographic and environmental stochasticity such as predation, competition (e.g., starvation), and senescence with old age. The extraction of groundwater from the aquifer's artesian zone represented a new and nearly constant stressor impacting both species' populations. Well mortality is currently the most direct and observable anthropogenic agent of mortality for both species. In Bexar County, the drilling of wells to meet public supply and irrigation demands began in the late 1880s (Livingston et al. 1936, p. 87; Petitt and George 1956, p. 44). The advent of groundwater supplies to an area with limited surface water was a significant factor in the growth of the City of San Antonio (Figure 18; Arnow 1959, pp. 3; Richter 2013, pp. 347–349). By 1907, 100 artesian groundwater wells had been drilled in Bexar County, with 20 of those at depths of >300 m (>984 ft) [Taylor 1907, pp. 55–56)]. Over 1,500 wells had been drilled in Bexar County by 1953, with 250 wells being large capacity (i.e., 25–76 centimeters (cm) [10–30 in] in diameter) [Petitt and George 1956, p. 44; Maclay 1995, p. 43]. San Antonio Public Service Company Well 4 (i.e., Well 164), drilled in 1942, discharged groundwater at a rate of 156,664,295 m3 (27,010 ac-ft) per year (Petitt and George 1956, p. 47). Additional large capacity wells, with outputs ranging from 11,705,743 m3 (9,490 ac-ft) to 29,714,577 m3 (24,090 ac-ft), were drilled during the 1950s across the City of San Antonio and Bexar County (Petitt and George 1956, p. 47; Arnow 1959, pp. 24, 29) (USFWS, 2022).

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Anthropogenic climate change has the potential to impact quantity of groundwater in the San Antonio segment (Green et al. 2011, pp. 538–546; Kløve et al. 2014, pp. 252–253, 258; Wuebbles et al. 2017, p. 14; Wineland et al. 2021, pp. 8–10). The Edwards Aquifer is considered among Texas' most vulnerable aquifers to climate change due to its dependence on precipitation for recharge and very rapid response to decreased or increased recharge (Loáiciga et al. 2000, pp. 192–193; Mace and Wade 2008, pp. 658, 662, 664–665; Loáiciga and Schofield 2019, p. 236; Ding

and McCarl 2020, p. 11). Reduced precipitation during dry periods is known to result in lower water levels in the Edwards Aquifer (Arnow 1959, pp. 21–24, 27–29). Changing climatic conditions, coupled with groundwater pumping, could lead to greater declines in aquifer water levels (Arnow 1959, pp. 21–24; Buszka 1987, pp. 24–27; Lindgren et al. 2004, p. 40). Between 1901 and 2016, annual average air temperature in the United States increased by 1.0 °C (1.8 °F), with temperatures expected to rise by 1.4 °C (2.5 °F) between 2021 and 2050 (Wuebbles et al. 2017, p. 17). Much greater temperature increases are projected into 2100 (Wuebbles et al. 2017, p. 17). Annual average air temperatures in the southern Great Plains, including Texas, are projected to increase by 2.0–2.8 °C (3.6–5.1 °F) by the mid-21st century (Kloesel et al. 2018, p. 995). Periods of extreme heat are expected to be more frequent, with number of days exceeding 38 °C (100 °F) increasing by an additional 30–60 days per year by the end of the 21st century (National Oceanic and Atmospheric Administration 2022, pp. 1-5; Kloesel et. al. 2018, pp. 990, 996). Downscaled climate projections for Bexar County were obtained from the U.S. Climate Resilience Toolkit (U.S. Federal Government, 2021). From 2022 to 2099, projections indicate that average daily maximum temperature will increase in that county from 28.3 °C (83 °F) in 2022 to 30 °C (86 °F) by 2099 under both high (Representative Concentration Pathway [RCP] 8.5) and low emissions (RCP 4.5). The average daily minimum temperature is projected to increase from 14.9 °C (58.9 °F) in 2022 to 19.2 °C (66.5 °F) in 2099 with high emissions and from 14.9 °C (58.9 °F) in 2022 to 16.7 °C (62 °F) under low emissions. Number of days per year above 40.5 °C (105 °F) in Bexar County are projected to increase from 2.3 days in 2022 to 52 days in 2099 with high emissions and from 4 days in 2022 to 13 days under low emissions. Average annual precipitation is not projected to change as markedly under high or low emission scenarios.

Stressor: Groundwater Contamination
Exposure:
Response:
Consequence:
Narrative: Contamination of groundwater by inorganic and organic substances has been identified as one of the primary stressors to stygobiont fishes globally (Proudlove 2021, pp. 202–203; Bichuette and Trajano 2010, pp. 68–70; Niemiller et al. 2013, p. 1,809). Karst aquifers are especially vulnerable to contamination given the high porosity and permeability of those systems which can rapidly transport groundwater over long distances (Kaçaroğlu 1999, pp. 340–343; Clark 2000, pp. 1–2; Vesper et al. 2003, pp. 1–2; Bichuette and Trajano 2010, pp. 68–70; Opsahl et al. 2018, p. 3; Mahler and Musgrove 2019, pp. 245–246; Guerra and Debbage 2021, p. 2). Surface water (e.g., precipitation, run-off, and streamflow) recharging karst aquifers is often focused to specific entry points (e.g., caves, fractures, and sinkholes) that provide little opportunity for filtration of dissolved and solid contaminants (Leibundgut 1998, pp. 46–47, 59; Kaçaroğlu 1999, pp. 337– 338, 340–342, 344–345). Anthropogenic contaminants can be introduced in several ways including 1) leaks from landfills, pipelines, petroleum storage tanks, septic tanks, and sewer lines, 2) spills of hazardous materials along roadways or railways and from petroleum extraction activities, 3) releases of untreated wastewater, and 4) land surface run-off from agricultural fields, impervious cover, and livestock operations (Vesper et al. 2003, p. 2; Johnson et al. 2009, p. 44; Burri et al. 2019, pp. 142–145). Abandoned water and petroleum wells that intersect aquifer formations represent another potential source of groundwater contamination. Contamination events may be acute, occurring over a few hours or days, or chronic, taking place over years to decades (Proudlove 2001, pp. 202–203; Niemiller et al. 2013, pp. 1,813–1,814). Major human activities that generate contaminants are agriculture (e.g., animal waste, fertilizers, herbicides, and pesticides), industry (e.g., hydrocarbons), and waste

management (e.g., septic tanks and sewage) [Vesper et al. 2003, pp. 2–10; Burri et al. 2019, pp. 142–145; Li et al. 2021, pp. 2–4]. Common inorganic contaminants are nitrogen (e.g., ammonia, nitrate, and nitrite), phosphorus, and heavy metals (e.g., zinc, mercury, and cadmium) [Burri et al. 2019, pp. 144– 145; Li et al. 2021, p. 3]. There are also hundreds of organic materials that can contaminate groundwater such as atrazine, benzene, chloroform, tetrachloroethene, and trichloroethene.

Recovery

Conservation Measures and Best Management Practices:

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Additional Threshold Information:

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References

USFWS. 2022. Species Status Assessment for the Toothless Blindcat (Trogloglanis pattersoni) and Widemouth Blindcat (Satan eurystomus). Version 2.0 November 1, 2022. Austin, TX. 120 pp + Appendices.

SPECIES ACCOUNT: *Scaphirhynchus albus* (Pallid sturgeon)

Species Taxonomic and Listing Information

Listing Status: Endangered; 09/06/1990; Mountain-Prairie Region (R6)

Physical Description

A large fish (to 186 cm) with a heterocercal tail, a long slender caudal peduncle, a flat shovel-shaped snout, four fringed barbels on the snout, a ventral mouth, and large bony scutes on the head, back, and sides; 37-43 dorsal rays; 24-28 anal rays (Page and Burr 1991) (NatureServe, 2015).

Taxonomy

The Pallid Sturgeon was first recognized as a species different from Shovelnose Sturgeon by S. A. Forbes and R. E. Richardson in 1905 based on a study of nine specimens collected from the Mississippi River near Grafton, Illinois (Forbes and Richardson 1905). They named this new species Parascaphirhynchus albus. Later reclassification assigned it to the genus Scaphirhynchus where it has remained (Bailey and Cross 1954; Campton et al. 2000) (USFWS, 2014).

Historical Range

The Pallid Sturgeon is native to the Missouri and Mississippi rivers. The historical distribution of the Pallid Sturgeon includes the Missouri and Yellowstone rivers in Montana downstream to the Missouri-Mississippi confluence and the Mississippi River possibly from near Keokuk, Iowa downstream to New Orleans, Louisiana (Coker 1929; Bailey and Cross 1954; Brown 1955; Carlson and Pflieger 1981; Kallemeyn 1983; Keenlyne 1989 and 1995) (USFWS, 2014).

Current Range

Range includes the Missouri River (from mouth to Fort Benton, Montana), lower Yellowstone River, lower Platte River, Mississippi River downstream from its junction with the Missouri River and upstream at least several kilometers from the Missouri River, and Atchafalaya River in central Louisiana (Reed and Ewing 1993, USFWS 2007). Occasional sightings have occurred near the mouths of various other large tributaries of the Mississippi River (e.g., Big Sunflower River and St. Francis River) and Missouri River (e.g., Kansas River and Platte River), but these instances may reflect fishes utilizing unusual flow conditions (USFWS 1989). The lower Yellowstone River and lower Platte River may be significant spawning tributaries (see USFWS 2007) (NatureServe, 2015).

Distinct Population Segments Defined

No

Critical Habitat Designated

No;

Life History

Feeding Narrative

Adult: Adults and immatures are piscivorous and invertivorous. Feeds opportunistically on aquatic insects, crustaceans, mollusks, annelids, eggs of other fishes, and sometimes other fishes (USFWS 1989) (NatureServe, 2015).

Reproduction Narrative

Adult: Females likely take at least several years to mature, and individuals probably spawn at intervals of several years. A 41-year-old female is the oldest reported individual of this species (Keenlyne et al. 1992, Trans. Am. Fish. Soc. 121:139-140) (NatureServe, 2015). Based on wild fish, estimated age at first reproduction was 15 to 20 years for females and approximately 5 years for males (Keenlyne and Jenkins 1993). Fecundity is related to body size. The largest upper Missouri River fish can produce as many as 150,000-170,000 eggs (Keenlyne et al. 1992; Rob Holm, USFWS Garrison Dam Hatchery, unpublished data), whereas smaller bodied females in the southern extent of the range may only produce 43,000-58,000 eggs (George et al. 2012). Spawning appears to occur between March and July. Spawning appears to occur adjacent to or over coarse substrate (boulder, cobble, gravel) or bedrock, in deeper water, with relatively fast, converging flows. In a hatchery environment, fertilized eggs hatch in approximately 5 - 7 days (Keenlyne 1995) (USFWS, 2014).

Geographic or Habitat Restraints or Barriers

Adult: Dams, waterfalls, upland habitat (NatureServe, 2015)

Spatial Arrangements of the Population

Adult: Linear (inferred from NatureServe, 2015)

Habitat Narrative

Adult: This species occupies large, turbid, free-flowing riverine habitat; it occurs in strong current over firm gravel or sandy substrate (USFWS 1989); it sometimes occurs in reservoirs (Kallemeyn 1981). Pallid sturgeons tend to select main channel habitats in the Mississippi River (Sheehan et al. 1998) and main channel areas with islands or sand bars in the upper Missouri River (Bramblett 1996). Separation barriers include dams lacking a suitable fishway, high waterfalls, and upland habitat (NatureServe, 2015). Pallid Sturgeon are a bottom-oriented, large river obligate fish. Bottom water velocities associated with collection locations are generally < 1.5 m/s (4.9 ft./s) (USFWS, 2014).

Dispersal/Migration

Motility/Mobility

Adult: High (inferred from USFWS, 2014)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Migrates to spawning areas (USFWS, 2014)

Dispersal

Adult: High (inferred from USFWS, 2014)

Dispersal/Migration Narrative

Adult: Adult Pallid Sturgeon can move long distances upstream prior to spawning; a behavior that can be associated with spawning migrations (U.S. Geological Survey 2007; DeLonay et al. 2009). Newly hatched larvae are predominantly pelagic, drifting in the currents for 11 to 13 days and likely dispersing several hundred km downstream from spawn and hatch locations (Kynard et al. 2002, 2007; Braaten et al. 2008, 2010, 2012a; Phelps et al. 2012) (USFWS, 2014).

Population Information and Trends

Population Trends:
Decline of 30-50% (NatureServe, 2015)

Species Trends:
Stable (USFWS, 2014)

Number of Populations:
6 (NatureServe, 2015)

Population Size:
6,000 - 21,000 (NatureServe, 2015)

Minimum Viable Population Size:
5,000 adults per management unit (USFWS, 2014)

Population Narrative:
Area of suitable riverine habitat has been reduced by at least 40 percent (i.e., about 60 percent of the historical range in the Mississippi River and lower Missouri River still has free-flowing river conditions, and the lower Missouri River continues to be negatively impacted by regulated flows and modified habitats) (USFWS 2007). This species has experienced a long term decline of 30-50%. The upper Missouri River supports a small, declining, wild population of a couple hundred adults; recruitment is very low or absent. The lower Missouri River contains a small wild population of probably fewer than 200 adults, with sporadic or limited recruitment. Population size in the Atchafalaya River may be a few thousand. Population size in the largest segments of the range--the Mississippi River--is unknown (USFWS 2007). According to Duffy et al. (1996), the total range-wide population size may be as few as 6,000 individuals or as many as 21,000. This species is represented by several distinct occurrences (subpopulations). USFWS (1993) recognized six "Recovery Priority Management Areas," which correspond with major continuous segments of the distribution that are more or less isolated from each other or that represent the major occupied river segments that are undivided by major barriers (NatureServe, 2015). Since listing, the status of the species has improved and is currently stable. Data indicate that genetic structuring exists within the Pallid Sturgeon’s range consisting of two distinct groups at the extremes of the species’ range with an intermediate group in the middle Missouri River (Campton et al. 2000; Tranah et al. 2001; Schrey 2007). The requirements of a minimum adult population capable of maintaining adaptive genetic variability long-term will need an effective population size (Ne) of at least 500 (Franklin and Frankham 1998) to perhaps as high as 5000 (Lande 1995). The minimum desired adult Pallid Sturgeon population within each management unit will be 5,000 (USFWS, 2014).

Threats and Stressors

Stressor: River alteration (USFWS, 2014)
Exposure:
Response:

Consequence:
Narrative: The species was essentially extirpated from approximately 28% of the historical range due to impoundment, and the remaining unimpounded range has been modified by channelization and bank stabilization, or is affected by upstream impoundments that alter flow regimes, turbidity, and water temperatures (Hesse et al. 1989; Keenlyne 1989; USFWS 2000a). River channelization, bank stabilization, impoundment, altered flow regimes, and their effects are documented throughout the range of the Pallid Sturgeon and each can negatively affect Pallid Sturgeon life history requirements. The most obvious effects to habitat are associated with the six main-stem Missouri River dams. These dams and their operations have: 1) truncated drift distance of larval Pallid Sturgeon (Kynard et al. 2007; Braaten et al. 2008), 2) created physical barriers that block normal migration patterns, 3) degraded and altered physical habitat characteristics, 4) greatly altered the natural hydrograph (Hesse et al. 1989), and 5) produced subtle changes in river function that influence both the size and diversity of aquatic habitats, connectivity (Bowen et al. 2003), and benthos abundance and distribution (Morris et al. 1968). Moreover, these large impoundments have replaced large segments of riverine habitat with lake conditions. River channelization, and bank stabilization within the Missouri River basin has altered river features such as channel morphology, current velocity, seasonal flows, turbidity, temperature, nutrient supply, and paths within the food chain (Russell 1986; Unkenholz 1986; Hesse 1987). In addition to the main-stem Missouri River dams, important tributaries like the Yellowstone, Platte, and Kansas rivers have experienced similar affects due to dams and water resource development, as well as bank stabilization efforts within their respective watersheds (USFWS, 2014).

Stressor: Water quality (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Tissue samples from three Missouri River Pallid Sturgeon and 13 other Pallid Sturgeon, mostly collected from the Mississippi River had metals (e.g., mercury, cadmium, and selenium), PCBs, and organochlorine pesticides (e.g., chlordane, dichloro-diphenyltrichloroethane, and dieldrin) at concentrations of concern (Ruelle and Keenlyne 1993; Ruelle and Henry 1994). Point-source discharges may adversely affect Pallid Sturgeon and their habitat. Wastewater treatment plant effluent can contain hormonally active agents. Endocrine disruption in fish exposed to estrogenic substances discharged by wastewater treatment plants is well documented (Purdom et al. 1994; Routledge et al. 1998; Cheek et al. 2001; Schultz et al. 2003). In addition to wastewater treatment plants, drinking water treatment plants also are a concern. In April 2004, several radio-tagged Pallid Sturgeon were repelled from the mouth of the Platte River immediately following a milky discharge from a drinking water treatment facility upstream (Parham et al. 2005). Further investigation found that the facility was not in compliance with its discharge permit which expired in 1993, and that the discharge likely contained several toxic irritants including ferric sulfate, calcium oxide, hydrofluosilicic acid, chlorine, and ammonia. Anthropogenic changes within the range of Pallid Sturgeon that affect dissolved oxygen concentrations could be affecting survival and recruitment. Measurements on the lower Missouri River from 2006-2009 showed that large rises in the river during spring and summer may result in dissolved oxygen levels falling to < 2 mg/l and remaining below 5 mg/l for several days (Blevins 2011). Dissolved oxygen levels of 3 mg/l and water temperatures of 22-26 oC (71.6- 78.8 oF) appeared lethal for juvenile Atlantic Sturgeon and Shortnose Sturgeon (Secor and Gunderson 1998; Campbell and Goodman 2004). The altered temperature profiles of riverine habitats

downstream from large bottom-release dams influence nearly every aspect of the life-history requirements and habitats of Pallid Sturgeon. While the magnitude of effects from altered temperature profiles vary by dam, they may be the most problematic in the inter-reservoir reservoir reaches of the impounded Missouri River (USFWs, 2014).

Stressor: Entrainment (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: The loss of Pallid Sturgeon associated with cooling intake structures for power facilities, towboat propellers, dredge operations, irrigation diversions, and flood control points of diversion has not been fully quantified, but entrainment has been documented. Scaphirhynchus larvae are weak swimmers and experience high rates of mortality under simulated propeller entrainment and high rates of stranding under simulated vessel-induced drawdown (Adams et al. 1999b; Killgore et al. 2001). Dredging in locations where Pallid Sturgeon congregate could result in entrainment and mortality. Entrainment of hatchery-reared Pallid Sturgeon has been documented in the irrigation canal associated with the Lower Yellowstone Irrigation Project's Intake Diversion Dam on the Yellowstone River (Figure 4) where some of these fish are believed to have perished (Jaeger et al. 2004). : Two hatchery-reared juvenile Pallid Sturgeon released in the Mississippi River and one adult hatchery-reared Pallid Sturgeon released in either the lower Missouri or middle Mississippi river were entrained by the Old River Control Complex as they were subsequently collected in the Atchafalaya River. During May and June 2008, 14 Pallid Sturgeon were collected behind the Bonnet Carré spillway (Reed in litt., 2008; USFWS 2009a) (USFWS, 2014).

Stressor: Climate change (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Within the range of Pallid Sturgeon, predicted affects appear to be shifts in runoff patterns: discharge peaks are anticipated to occur earlier and potentially be larger, late season river flows may be reduced, and water temperatures may rise (Intergovernmental Panel on Climate Change 2007). These changes to the water cycle are anticipated to affect water use (U.S. Global Change Research Program 2009), which may alter existing reservoir operations. Broadly, these potential effects to Pallid Sturgeon could be altered spawning behavior (i.e., movement and timing), reduced survival of early life stages and young-of-year, and reduced late-season habitat suitability due to reduced flows and presumably warmer temperatures. Another predicted outcome is increased or prolonged periods of drought (Intergovernmental Panel on Climate Change 2007; U.S. Global Change Research Program 2009). Increased water demand coupled with reduced late-season flows could significantly affect in-channel habitats which in turn may affect other species that are food items for Pallid Sturgeon (USFWS, 2014).

Stressor: Disease (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Viral Hemorrhagic Septicemia Virus is a fish disease that has caused large-scale mortalities in numerous species (Kim and Faisal 2010) and has been described as an "extremely

serious pathogen of fresh and saltwater fish" (APHIS 2006). While it has not been documented to affect Pallid Sturgeon, it also has not been found within the range of the species. However, Viral Hemorrhagic Septicemia Virus has been documented in the Great Lakes (APHIS 2006). Various shipping canals have created a connection between the Great Lakes and the Mississippi River so it is possible that through time, this virus could reach areas occupied by Pallid Sturgeon. Missouri River sturgeon iridovirus is a concern in the context of Pallid Sturgeon recovery because it causes mortality in hatchery-reared Pallid Sturgeon (Kurobe et al. 2011) and its effect on free-ranging sturgeon populations is unknown. This disease is known to cause substantial mortality in hatchery-rearing environments (Kurobe et al. 2011) (USFWS, 2014).

Stressor: Predation (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Habitat modifications that increase water clarity and artificially high densities of both nonnative and native predatory fishes could result in increased rates of predation. Pallid Sturgeon larvae and fry passively drift post-hatch (Kynard et al. 2007; Braaten et al. 2008). This behavior exposes naturally-spawned Pallid Sturgeon to predation which was moderated historically by high fecundity and turbid waters. However, anthropogenic changes that affect habitats could result in increased vulnerability to predation. In the impounded areas of the upper Missouri River, larvae may be transported into the clear headwaters of reservoirs like Fort Peck and Lake Sakakawea. These reservoirs are or have been artificially supplemented with predatory species like Walleye (Sander vitreus). Maintaining artificially elevated populations of certain species in these reservoirs has been hypothesized as a contributing factor in poor survival of larval and juvenile Pallid Sturgeon (USFWS, 2014).

Stressor: Energy development (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Exploration of natural gas and oil deposits occurs in portions of the Pallid Sturgeon's range. Preliminary assessment of the impacts of seismic air guns, a tool used for exploration, suggests that they may have negative effects on larval Pallid Sturgeon (Krentz in litt. 2010). The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration reports that there were 2.3 million miles of pipelines in the United States carrying natural gas and hazardous liquids (primarily petroleum, refined petroleum products, and other chemicals). Many pipelines cross rivers within the range of Pallid Sturgeon; some of which are buried under the river bed. Depending on the timing, magnitude, and the material leaked, a ruptured pipeline could pose a threat to Pallid Sturgeon (USFWS, 2014).

Stressor: Hybridization (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Experimental mating of Pallid Sturgeon with Shovelnose Sturgeon can produce living offspring (Kuhajda et al. 2007), accurate assessment of hybridization in the evolution of Scaphirhynchus and its relative threat to Pallid Sturgeon recovery will require statistically testing the hypothesis of hybridization against alternatives. Since hybridization is occurring in

Scaphirhynchus and likely has been occurring for many decades (Schrey et al. 2011), it is important to determine the cause (i.e., historical/natural or contemporary), extent, and frequency or rate of occurrence of hybridization (USFWS, 2014).

Stressor: Nonnative/nuisance aquatic species (USFWS, 2014)
Exposure:
Response:
Consequence:
Narrative: Several species with the potential for impacting Pallid Sturgeon have become established in parts of the species' range. These include the Asian carps (Common Carp (Cyprinus carpio), Grass Carp (Ctenopharyngodon idella), Silver Carp (Hypophthalmichthys molitrix), Bighead Carp (Hypophthalmichthys nobilis) and Black Carp (Mylopharyngodon piceus)) as well as the zebra mussel (Dreissena polymorpha). If food resources were limited from the presence of large populations of planktivores (e.g., Asian carps), early life-stage Pallid Sturgeon could face increased competition with native planktivorous fishes such as Gizzard Shad (Dorosoma cepedianum), Bigmouth Buffalo (Ictiobus cyprinellus) and Paddlefish (Kolar et al. 2005). Several authors have expressed concern that, because nearly all fish feed on zooplankton as larvae and juveniles, Asian carps have high potential to impact native fishes in the Mississippi River basin (Laird and Page 1996; Chick and Pegg 2001; Chick 2002). In addition to directly competing for food resources, Asian carps also could affect recruitment by predation on Pallid Sturgeon eggs or drifting larvae. Zebra mussel colonization has occurred in areas occupied by Pallid Sturgeon but data are limited on direct effects. In juvenile Lake Sturgeon, data show that zebra mussel occupancy changes the nature of the bottom substrates and a reduced foraging effectiveness with mussel presence resulting in avoidance of those areas by study fish more than 90% of the time (McCabe et al. 2006) (USFWS, 2014).

Recovery

Reclassification Criteria:
1. The listing/recovery factor criteria are sufficiently addressed such that a self-sustaining genetically diverse population of 5,000 adult Pallid Sturgeon is realized and maintained within each management unit for 2 generations (20-30 years) (USFWS, 2014).

2. Habitat conservation and restoration efforts establish and maintain riverine habitats capable of meeting and sustaining all life history requirements of the species (i.e., sufficient habitat is available to support a self-sustaining population within each management unit (USFWS, 2014).

3. Regulations and enforcement provide reasonable assurances that water quality parameters and contaminants of concern meet or exceed the latest national recommended water quality criteria (e.g., U.S. Environmental Protection Agency 2009) (USFWS, 2014).

4. Entrainment losses from all sources (i.e., water cooling intake structures, dredge operations, irrigation diversions, etc.) are minimized such that attributable mortality does not impair maintenance of self-sustaining populations (USFWS, 2014).

5. The potential effects associated with changes in climate are assessed and mitigated or minimized (USFWS, 2014).

7. Sufficient data to assess the effects of intraspecific competition from nonnative/invasive species are available, and, if needed, regulations and management measures are established to minimize competition and predation threats to the species (USFWS, 2014).

8. Adequate mechanisms are in place and enforcement provide reasonable assurance that excessive non-natural mortality is reduced to sustainable levels and adequate regulations protect habitat and habitat forming processes sufficient to maintain self-sustaining populations within each management unit or when the underlying threat has been addressed such that regulatory mechanisms are no longer needed (USFWS, 2014).

9. Energy development and new technologies are evaluated and assessed and, if necessary, measures are implemented to minimize any adverse effects from these activities (USFWS, 2014).

10. Once simulation studies can assess if alterations of habitats have influenced temporal or spatial reproductive isolating mechanisms resulting in increased rates of hybridization, this threat will likely be addressed by both site-specific and ecosystem improvement efforts such that actual risks associated with pallid/shovelnose hybridization are mitigated (USFWS, 2014).

11. Invasive species or aquatic nuisance species are regulated and reduced such that deleterious effects (i.e., predation and competition) are minimized (USFWS, 2014).

6. Take of Pallid Sturgeon associated with commercial, recreational, scientific or educational uses is fully controlled by State regulation, and has little to no effect upon the sustainability of the species within each management unit (USFWS, 2014).

Delisting Criteria:
The criteria for reclassification to threatened status have been met and sufficient regulatory mechanisms are established to provide reasonable assurances of long-term persistence of the species within each management unit in the absence of the Act's protections (USFWS, 2014).

Recovery Actions:
- Conserve and restore Pallid Sturgeon individuals, populations, and habitats (USFWS, 2014).
- Conduct research necessary to promote survival and recovery of Pallid Sturgeon (USFWS, 2014).
- Obtain information on population genetics, status, and trends (USFWS, 2014).
- Maintain the Pallid Sturgeon Conservation Augmentation Program where deemed necessary (USFWS, 2014).
- Coordinate and implement conservation and recovery of Pallid Sturgeon (USFWS, 2014).
- Post downlisting or delisting planning (USFWS, 2014).
- Within the Missouri River basin, where channelization and dams have fragmented habitats and altered natural riverine processes and no evidence for Pallid Sturgeon recruitment exists, many efforts are being explored or implemented to restore ecological function, as well as utilizing the PSCAP to prevent local extirpation. Restoration efforts include, but are not limited to: creating side channel habitats, restoring connectivity to backwater areas, notching dikes, providing fish passage, and manipulating flows through the dams. In addition to habitat restoration efforts and the PSCAP, a basin-wide Pallid Sturgeon population monitoring program has been established to track changes in species abundance

and status (USFWS, 2014).

- During 1995, 1997, and 2002, the Bureau of Reclamation provided a June peak release in the fort Benton to Fort Peck Reservoir, Montana of 4,080, 4,500, and 5,300 cfs, respectively, to benefit downstream fisheries. Augmentation and monitoring efforts continue to support and evaluate the Pallid Sturgeon population within this reach (USFWS, 2014).
- In addition to artificial supplementation with hatchery-reared Pallid Sturgeon, discussions and exploratory designs have been ongoing in an effort to increase water temperatures in the Missouri River immediately downstream of Fort Peck Dam. Several options have been considered ranging from releasing surface water over the spill-way to modifying the intake structures or installing a large "curtain" around the intakes such that they draw down and release warmer surface waters. To date, warm water releases have not been implemented due in part to insufficient water levels. The Yellowstone River is the largest tributary to the Missouri River in this reach. A multi-agency effort has been ongoing since the early 2000s to develop and implement fish passage and entrainment protection at Intake Dam. In 2007, the Water Resources Development Act provided the U.S. Army Corps of Engineers the authority to assist the Bureau of Reclamation with design and implementation of fish passage and entrainment protection at Intake Dam. A new water diversion structure, complete with fish screens, was initiated in 2010 and operational in 2012. Final passage options, intended to maximize Pallid Sturgeon passage probabilities to areas upstream of Intake Dam, are still being developed (USFWS, 2014).

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SPECIES ACCOUNT: *Scaphirhynchus suttkusi* (Alabama sturgeon)

Species Taxonomic and Listing Information

Listing Status: Endangered; 5/5/2000; Southeast Region (R4) (USFWS, 2015)

Physical Description

This fish is the smallest of North American sturgeon growing to about 80 cm and 1-2 Kg at maturity with a maximum Standard Length of about 72 cm. The body is elongated and is broadly flattened at the snout; the body narrows abruptly towards the tail. It is heavily armored. The upper coloration is light tan to yellow and the belly is creamy white. (USFWS 2013)

Taxonomy

This species formerly was included in S. platorhynchus; it was described as a distinct species by Williams and Clemmer (1991). There has been disagreement over whether the Alabama sturgeon warrants species status (see USFWS 1999 and Boschung and Mayden 2004 for discussion). Studies by Campton et al. (2000) and Kuhajda (2002), and other research cited by Boschung and Mayden (2004), are consistent with recognition of S. suttkusi as a distinct species. Krieger et al. (2000) examined phylogenetic relationships of North American sturgeons based on mtDNA sequences and found that nucleotide sequences for all four examined genes for the three Scaphirhynchus species were identical (NatureServe, 2015). Subsequent genetic analyses by Campton et al. (2000), Simons et al. (2001), and Ray et al. (2007) demonstrate sufficient genetic differences between Alabama and shovelnose sturgeons to separate them. Today, the Alabama sturgeon is considered a valid species both nationally and internationally (Nelson et al. 2004, Eschmeyer 2010, Integrated Taxonomic Information System (ITIS) 2010, International Union for Conservation of Nature (IUCN) 2010). (USFWS, 2010)

Historical Range

The historical range of the Alabama sturgeon included nearly every major basin in the Mobile River basin downstream of the Fall Line, comprising nearly 1,600 km (994 mi) of riverine habitat in the Mobile River Basin in Alabama and Mississippi. There are records of Alabama sturgeon from nearly all the major rivers in the Mobile River Basin below the Fall Line, including the Black Warrior, Tombigbee, Alabama, Coosa, Tallapoosa, Mobile, Tensaw, and Cahaba Rivers (Burke and Ramsey 1985). However, over the last century, the species has disappeared from at least 85 percent of its historical range, and since the 1960s has experienced a significant decline in the remaining range (USFWS 2009). There are historical records of Alabama sturgeon from nearly all the major rivers in the Mobile River Basin including the Black Warrior, Tombigbee, Alabama, Coosa, Tallapoosa, Mobile, Tensaw, and Cahaba Rivers (Burke and Ramsey 1985, 1995). (NatureServe, 2015)

Current Range

Range is limited to the Mobile Basin in Alabama and Mississippi. Recent collections (since 1990) of the Alabama sturgeon are confined to the lower Alabama River from its confluence with the Tombigbee River upstream to R.F. Henry Lock and Dam, including the lower Cahaba River (Rider and Hartfield 2007) (USFWS, 2013), with only one of these (in 1996) being above Claiborne (Millers Ferry) Lock and Dam. The current known range is in Clarke, Monroe, and Wilcox counties (NatureServe, 2015)

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 6/2/2009.

Legal Description

On June 2, 2009, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Scaphirhynchus suttkusi (Alabama sturgeon) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes one critical habitat unit (CHU) in Alabama (74 FR 26488-26510).

Critical Habitat Designation

The critical habitat designation for Scaphirhynchus suttkusi includes one CHU in Autauga, Baldwin, Bibb, Clarke, Dallas, Lowndes, Monroe, Perry, and Wilcox Counties, Alabama. The critical habitat unit encompasses 524 km (326 mi) of river channel (74 FR 26488-26510).

Unit: Alabama and Cahaba Rivers; Baldwin, Monroe, Wilcox, Clarke, Dallas, Lowndes, Autauga, Perry, and Bibb Counties, Alabama. (i) The unit encompasses 524 km (326 mi) of river channel. The portion of river channel in the Alabama River extends 394 km (245 mi) from its confluence with the Tombigbee River, Baldwin and Clarke Counties, Alabama, upstream to R.F. Henry Lock and Dam, Autauga and Lowndes Counties, Alabama; and the portion of river channel in the Cahaba River extends 130 km (81 mi) from its confluence with the Alabama River, Dallas County, Alabama, upstream to U.S. Highway 82, Bibb County, Alabama.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Scaphirhynchus suttkusi critical habitat consists of five components in Alabama (74 FR 26488-26510):

(i) A flow regime (i.e., the magnitude, frequency, duration, seasonality of discharge over time) necessary to maintain all life stages of the species in the riverine environment, including migration, breeding site selection, resting, larval development, and protection of cool water refuges (i.e., tributaries).

(ii) River channel with stable sand and gravel river bottoms, and bedrock walls, including associated mussel beds.

(iii) Limestone outcrops and cut limestone banks, large gravel or cobble such as that found around channel training devices, and bedrock channel walls that provide riverine spawning sites with substrates suitable for embryo deposition and development.

(iv) Long sections of free-flowing water to allow spawning migrations and development of embryos and larvae.

(v) Water temperature not exceeding 32° Celsius (90° Fahrenheit); dissolved oxygen levels not less than 5 milligrams per liter (mg/L) (5 parts per million (ppm)), except under extreme conditions due to natural causes or downstream of existing hydroelectric impoundments, where it can range from 5 mg/L to 4 mg/L (5 ppm to 4 ppm); and pH within the range of 6.0 to 8.5.

Life History

Feeding Narrative

Adult: The diet includes larval aquatic insects, oligochaetes, mollusks, fish eggs, and fishes; may scavenge (Williams and Clemmer 1991, USFWS 1994). A diet that includes odonates and ephemeroptera suggests foraging in sandy depositional areas with very little silt and slow to moderate flow (Mayden and Kuhajda 1996), but other insects in the diet suggest both rocky and soft substrates, as well as mid-water column. (USFWS, 2009)

Reproduction Narrative

Adult: Species is rare enough that little is known. It apparently migrates upstream for spawning (USFWS, 2013) in spring (Williams and Clemmer 1991). Adhesive eggs attach to hard bottom surface and probably hatch in about a week or somewhat less. Larvae are planktonic and drift for about 12-13 days, before (inferred from other sturgeon) settling to a benthic existence. Adults may exhibit downstream migrations after spawning in search of feeding and summer refugia, but they stay above the more saline areas. Adults are typically 5-7 years old at first reproduction and may only reproduce at 2-3 year intervals (USFWS, 2013).

Geographic or Habitat Restraints or Barriers

Adult: Fall line, dams, high water temperature or salinity (USFWS, 2013)

Environmental Specificity

Adult: Broad within long, open reaches (USFWS, 2013)

Habitat Narrative

Adult: The habitat includes the main channels of major rivers in areas below the Fall Line; most specimens have been taken in moderate to swift current at depths of 6-14 meters, over sand and gravel or mud; several records are from oxbow lakes (Williams and Clemmer 1991). This species apparently prefers relatively stable substrates of gravel and sand in river channels with swift currents. Most captures have been within 300 M of a sandbar. (USFWS, 2013)

Dispersal/Migration

Motility/Mobility

Egg: None (adhesive) (USFWS, 2013)

Larvae: Drift (USFWS 2013)

Adult: High (USFWS, 2013)

Migratory vs Non-migratory vs Seasonal Movements

Adult: Seasonal movements (USFWS, 2013)

Dispersal

Larvae: By drift (USFWS 2013)

Adult: Limited to favorable riverine habitat (USFWS, 2013)

Dispersal/Migration Narrative

Larvae: Larvae are planktonic and drift for 12-13 days. Alabama Sturgeon may require some minimum distance of flowing river conditions for development of larval to juvenile stage, and for sustainable recruitment of the species (USFWS 2013).

Adult: Alabama sturgeon are capable of considerable movement, but only within their large river habitat where there are no barriers. They migrate upstream to spawn, and after spawning they migrate downstream to feed and find summer refugia. (USFWS, 2013)

Population Information and Trends

Population Trends:

Decreasing (USFWS, 2013)

Species Trends:

Decreasing (USFWS, 2013)

Number of Populations:

1 - 5 (NatureServe, 2015)

Population Size:

1 - 1000 individuals (NatureServe, 2015)

Minimum Viable Population Size:

500 (USFWS, 2013)

Population Narrative:

The species was formerly abundant as indicated by commercial fishing from the 1890s into the middle of the twentieth century. Following considerable impoundments, channelization, and other habitat alteration, the extent of occurrence, area of occupancy, and abundance have declined over the past several decades; the species now inhabits about 15 percent of the historical range; formerly common, the Alabama sturgeon is now nearly extinct (USFWS 1994, 2013). Several individuals captured in the 1990s and as recently as 2007 were all males. Decline of 70-90% total population size of this rare species, which probably does not exceed a couple hundred, may be less than that required for long-term viability. As of 2002, only 40 specimens were known from museum records or photographic documentation (Boschung and Mayden 2004). All recent specimens have been from one river. (NatureServe, 2015). With only three documented occurrences in the last nineteen years, it is likely that the Alabama sturgeon is extremely rare (Rider and Powell 2009, IUCN 2010, Kuhajda and Rider 2016). (USFWS, 2020)

Threats and Stressors

Stressor: Hydrological alteration of habitat (NatureServe, 2015)
Exposure: Indirect (NatureServe, 2015)
Response: Impaired mobility and dispersal (NatureServe, 2015)

Consequence: Limited habitat (NatureServe, 2015)
Narrative: This and the other species of Scaphirhynchus declined over past several decades, due primarily to habitat loss, degradation, and fragmentation resulting from impoundments, regulated flows, dredging, channelization, and siltation (Williams and Clemmer 1991). Dredging to maintain navigation currently is not perceived as a threat to the sturgeon or its habitat (USFWS 1994). Past commercial over-exploitation probably contributed to the decline. (NatureServe, 2015)

Stressor: Non-point source pollution (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: Mining, toxic chemical spills, siltation, agriculture, runoff and discharge of organic and inorganic pollutants, channelization, dredging, streambank erosion, and other forms of non-point source pollution continue to impact the Alabama sturgeon and its habitat. Many of these impacts typically occur during the summer and fall months when flows are at their low point. Low stream flows tend to concentrate pollutants. (USFWS, 2010)

Stressor: Small population size (USFWS, 2010)
Exposure:
Response:
Consequence:
Narrative: The primary issues affecting the Alabama sturgeon are its small population size and its apparent inability to successfully recruit. Recent information suggests that long stretches of uninterrupted flows are necessary for Scaphirhynchus sturgeons to successfully recruit. (USFWS, 2010). The species is vulnerable to the usual problems associated with small population size. This is exacerbated by the lack of information on habitat and life history requirements. (NatureServe, 2015)

Recovery

Reclassification Criteria:
Downlisting to "threatened" status is potential when (1) there are viable populations in the Alabama and Cahaba Rivers. This would consist of approximately 500 sexually mature Alabama Sturgeon shown to be surviving and naturally reproducing in the Alabama/Cahaba. (USFWS, 2013)

(2) population studies show that the Alabama Sturgeon population is naturally recruiting (consisting of multiple age classes) and sustainable over a period of 20 years (2-3 generations), and no longer requires hatchery augmentation. (USFWS, 2013)

(3) an agreement is in place that ensures adequate flows are being delivered currently and into the future, down the Alabama River to allow for successful development of sturgeon larvae, and that fish are being successful being passed both upstream and downstream at dams on the Alabama River. (USFWS, 2013)

Delisting Criteria:

1. At least 2 populations exhibit a stable or increasing trend, natural recruitment, and multiple age classes. 2. The Alabama River Basin and the Tombigbee River Basin are each occupied by at least 1 population, and sufficient length of unimpeded continous flowing river is available in each river basin. 3. Threats have been addressed and/or managed to the extent that the species will be viable into the forseeable future (USFWS, 2019)

Recovery Actions:

- Annual collection efforts are necessary to capture Alabama Sturgeon broodstock for a captive propagation effort, since the current, primary threat to the Alabama Sturgeon is its small population size and its apparent inability to offset mortality rates with current recruitment rates. This action includes annual collection efforts to obtain broodstock, completing and maintaining hatcheries, and developing protocols to maximize the chance of success. Once hatchery production is underway, plans are needed to augment and restock the rivers. Criteria for optimal sizes and methods for stocking with maximum potential of diverse and healthy fish need to be developed, as well as a monitoring pan for released fish. (USFWS, 2013)
- Hatcheries need to be completed and maintained, and protocols need to be developed to maximize the chance of success. Once hatchery production is underway, plans are needed to augment and restock the rivers. Criteria for optimal sizes and methods for stocking with maximum potential of diverse and healthy fish need to be developed, as well as a monitoring plan for released fish. (USFWS, 2013)
- It needs to be determined if spawning or non-spawning sturgeon can be attracted to dam locks to enhance fish passage at Claiborne and Miller’s Ferry Locks and Dams. (USFWS, 2013)
- Existing habitat in the Alabama River needs to be protected and enhanced. This includes using federal and state permitting processes to maintain channel integrity and riverine functions, identifying and monitoring stable habitats, and developing State sand and gravel mining regulations to protect the riverine habitats. State monitoring efforts to protect water quality and maintain minimum stream flow are important, along with sediment studies. (USFWS, 2013)
- Basic biological studies are needed on the life history, specific habitat usage, movements of adult and juvenile fishes, prey density to identify important feeding areas, and similar parameters to enhance the limited knowledge of the Alabama Sturgeon. (USFWS, 2013)
- Coordination with other agencies and groups are necessary to modify and revise objectives, as needed. Also important are free exchange of information on collection, propagation, reintroduction, and management of various sturgeon species that may aid in recovery. (USFWS, 2013)
- Continue efforts to pursue fish passage and/or bypass at all dams on the Alabama River. (USFWS,2010)
- Work with the Corps to improve operations at Claiborne, Millers Ferry, and R. F. Henry lock and dams by increasing the amount of free-flowing habitat available within the reservoirs. (USFWS, 2010)
- Continue to monitor population levels, demographics, and habitat conditions of existing populations. This includes annual attempts to collect individuals for propagation and tracking. (USFWS, 2010)
- Continue efforts aimed at obtaining individuals and improving techniques necessary for captive propagation of the species. (USFWS, 2010)

- Continue efforts to identify locations along the Alabama and Cahaba Rivers for suitable spawning habitat. (USFWS, 2010)
- Better understand the relationship between water quality and upstream dam releases, and continue monitoring seasonal and diurnal changes in water quality in the Alabama River. (USFWS, 2010)
- Continue efforts to reduce non-point source pollution from agricultural activities by working through the Partners for Fish and Wildlife, Farm Bill, and other landowner incentive programs that implement best management practices. (USFWS, 2010)
- While continuing to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat, encourage water quality regulatory agencies to develop new criteria suitable for the species they are intended to protect. (USFWS, 2010)

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Continue efforts to pursue fish passage and/or bypass at all dams on the Alabama River. Investigate the habitat and fish passage needs on the Tombigbee River. Work with the Corps to improve operations, including base-flow operations, at Claiborne, Millers Ferry, and R.F. Henry Locks and Dams by increasing the amount of free-flowing habitat available within the reservoirs. Continue to monitor population levels, demographics, and habitat conditions. Investigate different methods to attempt to estimate population sizes given the limited captures in the past. This includes attempts to collect individuals for telemetry studies. Continue efforts aimed at obtaining individuals and improving techniques necessary for captive propagation of the species. Continue efforts to identify locations along the Alabama and Cahaba Rivers for suitable spawning habitat. Better understand the relationship between water quality and upstream dam releases, and continue monitoring seasonal and diurnal changes in water quality in the Alabama River. Continue efforts to reduce non-point source pollution from agricultural activities by working through the ADEM, Alabama Department of Transportation, Alabama Forestry Commission, Natural Resource Conservation Service (NRCS), the Service's Partners for Fish and Wildlife, and all other landowner incentive programs that encourage and implement best management practices. While continuing to utilize existing legislation and regulations (Federal and State endangered species laws, water quality requirements, stream alteration regulations, etc.) to protect the species and its habitat, encourage water quality regulatory agencies to develop new criteria suitable for the species they are intended to protect. Explore the use of eDNA detection techniques to aid collection efforts to obtain individuals necessary for captive propagation efforts by potentially reducing sampling time, identifying productive target sampling area(s), and increase sampling efficiency. (USFWS, 2020)

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Designation of Critical Habitat for Alabama Sturgeon (Scaphirhynchus suttkusi)

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SPECIES ACCOUNT: *Speoplatyrhinus poulsoni* (Alabama cavefish)

Species Taxonomic and Listing Information

Listing Status: Endangered; 10/11/1977; Southeast Region (Region 4) [USFWS 1990]

Physical Description

The Alabama cavefish is an eyeless, pink-white fish with a flattened head, with a body length of up to about 7 cm [NatureServe 2015]. The integument, fins, fin rays, and elements of the cranial skeleton are quite transparent. The fish has no externally visible eyes, and probably no internal optical structures [USFWS 1990].

Taxonomy

This species belongs to the family Amblyopsidae [USFWS 1990].

Historical Range

There is no historical range/distribution information beyond the current range/distribution [inferred from USFWS 1990 and NatureServe 2015].

Current Range

This species is known from only Key Cave in Lauderdale county, Alabama and may be an endemic relict in this aquatic system. The fish's distribution is characteristic of relics, i.e. a limited area at the periphery of a broader family range [USFWS 1990]. A survey of 120 other caves in the region, conducted since 1977, failed to locate any other populations [NatureServe 2015].

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 9/9/1977.

Legal Description

On September 9, 1977, the Service designated critical habitat for the Alabama cavefish (Speoplatyrhinus poulsoni) under the Endangered Species Act, as amended (42 FR 45526 - 45530).

Critical Habitat Designation

The critical habitat designation for Speoplatyrhinus poulsoni occurs in Lauderdale county, Alabama. The Final Rule states " More Specific locality data for Federal agencies fulfilling their obligations under Section 7 of the Endangered Species Act of 1973 can be obtained from the Office of Endangered Species, U.S. Fish and Wildlife Service, Washington, DC 20240."

Primary Constituent Elements/Physical or Biological Features

Not described. It is troglobitic cave fish known only from a cave in Lauderdale County, Alabama. It can be inferred that bats and clean groundwater are required by this species.

Special Management Considerations or Protections

It is threatened by disruption of the ecosystem through interference with bat populations and groundwater pesticide pollution due to agricultural operations. A proposed industrial park in this area constitutes an additional threat. Few eggs are produced per female and reproduction does not occur every year.

Life History

Feeding Narrative

Adult: The Alabama cavefish is an invertivore that feeds on a diverse distribution of small aquatic invertebrates and smaller cavefishes [NatureServe 2015]. Feeding strategy is best described as generalist and confined to the Key Cave. Growth rates are low compared to main competitors, two species of cave crayfish [USFWS 1990]. In Key Cave, guano of the gray bat probably is the major source of organic matter [NatureServe 2015].

Reproduction Narrative

Adult: The Alabama cavefish is oviparous and a branchial brooder. Clutch size is presumed to be similar to the northern cavefish, Amblyopsis spelaea, which produces on average 30 female and 15 male fry that survive to leave the gill chamber. After spawning little parental care is given. Fitness is inferred to be moderate based on the currently stable populations today. The average lifespan is 5-10 years. The species does not appear to be dependent on other species for reproduction, however seasonal flooding of caves may trigger hormonal and other changes in cavefish, thereby stimulating growth and reproduction. Cavefish show an increase in longevity and a decrease in population growth rate with increasing restriction to caves [USFWS 1990].

Spatial Arrangements of the Population

Adult: Random [inferred from USFWS 1990]

Environmental Specificity

Adult: Broad/generalist [inferred from USFWS 1990]

Tolerance Ranges/Thresholds

Adult: Moderate; likely sensitive to seasonal flooding events, which are presumed to be consistent [inferred from USFWS 1990]

Site Fidelity

Adult: Moderate [inferred from USFWS 1990]

Habitat Narrative

Adult: The Alabama cavefish inhabits a single freshwater cave (Key Cave) that is subject to seasonal flooding events that wash organic matter into the subterranean water system [NatureServe 2015]. The population is presumed to be randomly distributed. Broad/generalist behavior is exhibited. Ecological integrity of the community is presumed to be moderate, as are tolerance ranges/thresholds and site fidelity behavior. Clear lentic subterranean waters are important to maintain the integrity of the species [USFWS 1990].

Dispersal/Migration

Motility/Mobility

Adult: Low due to the geological constraint of the Key Cave [inferred from USFWS 1990]

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migratory [NatureServe 2015]

Dispersal

Adult: Low [inferred from USFWS 1990]

Immigration/Emigration

Adult: None [inferred from USFWS 1990]

Dependency on Other Individuals or Species for Dispersal

Adult: None [inferred from USFWS 1990]

Dispersal/Migration Narrative

Adult: The species is physically constrained within the Key Cave aquifer region, hence exhibits low molitity/mobility, no migration [NatureServe 2015], low dispersal, no immigration/emigration, and no dependency on other individuals or species for dispersal or migration [inferred from USFWS 1990]

Population Information and Trends

Population Trends:

Unknown [USFWS 1990]

Population Growth Rate:

Stable

Number of Populations:

4 [inferred from USFWS 1990]

Population Size:

<100 (USFWS, 2023)

Adaptability:

Low to moderate, based on specialized habitat conditions but diverse potential food supply [inferred from USFWS 1990]

Population Narrative:

Population trends for the Alabama cavefish are unknown. As of 1977 there were four known populations (though not named). The species is presumed to exhibit low resiliency, representation, and redundancy. The species may show low-moderate adaptability based on specialized habitat conditions but diverse potential food supply [inferred from USFWS 1990]. The species is considered extremely rare with a total population estimate of less than 100 individuals. Though the Key Cave entrance and 429 ha (1060 ac) of surface property above the cave is partially protected due to its ownership by the Service, full protection is not afforded to areas on private lands, including portions of the aquifer and sink holes in the recharge area (USFWS, 2023).

Threats and Stressors

Stressor: Groundwater degradation [USFWS 1990]
Exposure:
Response:
Consequence:
Narrative: Groundwater degradation caused by toxins, nutrient fertilizers, sewage and the inflow of lower quality water could have far-reaching effects on the Alabama cavefish. This aquatic, environment related stress will likely reduce longevity and reproductive capability [USFWS 1990].

Stressor: Alteration in drainage and hydrologic patterns
Exposure:
Response:
Consequence:
Narrative: Alterations in drainage and hydrologic patterns affect aquifer recharge capabilities. In addition to reducing flow rates in cave streams, the input of organic matter may be reduced when surface drainage is altered. This directly affects the cavefish's food supply and reproductive capabilities [USFWS 1990].

Stressor: Lower ground water levels
Exposure:
Response:
Consequence:
Narrative: The lowering of groundwater levels may also occur from increased pumping of groundwater. Permanent lowering of the water table could reduce aquatic troglobitic habitat and isolate it from extrinsic energy sources. Planned industrial development of the Key Cave area could alter drainage and hydrological patterns within the recharge area for Key Cave [USFWS 1990].

Stressor: Collecting
Exposure:
Response:
Consequence:
Narrative: Collecting for novelty value or for scientific or educational purposes could be devastating to the population. The larger individuals of other more common cavefish are the most frequently taken. Such taking of the Alabama cavefish would represent a reduction of an already tenuous breeding population [USFWS 1990].

Stressor: Diminished organic matter inputs
Exposure:
Response:
Consequence:
Narrative: Diminished organic matter inputs adversely impact the aquatic food base in many caves. In Key Cave, the gray bat maternity colony is perhaps the primary source of organic input by deposition of guano. The status of the gray bat in Key Cave is important to the status of the Alabama cavefish [USFWS 1990].

Stressor: Pesticide Use (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: Future threats from pesticide use will continue to be a concern for the Alabama cavefish and its critical habitat. In 2017 the U.S. Environmental Protection Agency (EPA) began the registration review for the mosquito control pesticide, malithion. The EPA determined that the pesticide was likely to adversely affect listed species and contacted the Service for consultation. As with many other fish in the review, it was determined the Alabama cavefish would experience a high risk of mortality if exposed to this pesticide (EPA 2022: Service 2022). It was also determined that aquatic invertebrates, an important food source for the Alabama cavefish, would also suffer from a high risk of mortality if exposed to this chemical. If malathion (and other related chemicals in the future) are approved by the EPA for use, it is vitally important that the product labels and instructions be strictly adhered to. While risks exist, responsible use of the chemical and implementation of mitigation measures developed though an interagency effort by the Service, EPA, and U.S. Department of Agriculture, will minimize negative impacts to the Alabama cavefish and other aquatic species (EPA 2022: Service 2022) (USFWS, 2023)

Stressor: Gray Bat Population (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: A gray bat (Myotis grisescens) colony in Key Cave is likely the primary source of organic matter through the deposition of guano, which is likely the foundation of the food web in the ecosystem (Service 1990). Because gray bats provide a major source of nutrients to the cave ecosystem, we can infer that a positive relationship exists between the gray bat and Alabama cavefish populations, therefore conservation of the cavefish may depend on conservation actions undertaken for the bat (Tuttle 1979). White-nose syndrome is causing increased bat mortality and population losses due to impacts on the species during hibernation and emergence (Reeder et al. 2012, Verant et al. 2014). During the last 15 years, the reduction of bat populations and guano deposits in Key Cave (Gates 2014 and 2015, pers. comm.) may have reduced the nutrient cycling in cave waters (Kuhajda 2004b), as it has in other cave systems. The loss of this important food source could have direct and indirect effects on the cavefish since diminished organic matter input adversely impacts the aquatic food base in caves (USFWS, 2023)

Stressor: Agricultural Impacts (USFWS, 2023)
Exposure:
Response:
Consequence:
Narrative: The Alabama cavefish and immediate recharge area are protected within the Key Cave NWR including approximately 242 hectares (598 ac) of farmland and old fields (Figure 2). The NWR System Improvement Act of 1997 requires that every NWR develop a Comprehensive Conservation Plan (CCP) to identify management actions for the Refuge to meet the refuge's purpose and revise it every 15 years, as needed. The CCPs allow NWR managers to take actions that improve the condition of habitats and that benefit wildlife including fish species such as the Alabama cavefish. Agriculture can have both positive and negative effects to the Alabama cavefish. Key Cave NWR relies on cooperative farming agreements to manage the land around Key Cave. Without these agreements, the NWR would likely be overrun with invasive species,

such as: Johnsongrass (Sorghum halepense), Chinese privet (Ligustrum sinense), green ash (Fraxinus pennsylvanica), sweetgum (Liquidambar styraciflua) trumpet vine (Campsis radicans), and bradford pear (Pyrus calleryana) to list a few (Hurt 2022, pers. comm). Invasive species can use more water than their native counterparts and could impact hydrology that feeds the habitat the Alabama cavefish relies on for survival (Cavaleri and Sack 2010). Although there are some concerns with the use of agricultural chemicals in the Key Cave recharge area, precautions have been put in place to minimize impacts, to include the use of buffer zones and restrictions on spraying. While long-term goals of the refuge are to convert agricultural land to native grass or oak savannah habitat, until adequate funding is available, active farming within the refuge plays an important role in conditions of water quality in Key Cave and the surrounding recharge area (Hurt 2022, pers. comm) (USFWS, 2023).

Recovery

Reclassification Criteria:
When three other viable populations are found in discontinuous aquatic systems outside the Key Cave area [USFWS 1990];

the recharge areas for all four populations are protected [USFWS 1990];

all four populations are demonstrated to be stable or increasing over at least a 20-year period [USFWS 1990].

Criterion 1. Existing population in Key Cave demonstrates a stable or increasing trend, evidenced by natural recruitment and multiple age classes (addresses Factor A, E). Criterion 2. Two (2) additional populations are discovered or established that demonstrate a stable or increasing trend, evidenced by natural recruitment and multiple age classes (addresses Factor A, E). Criterion 3. The aquifer recharge areas for these populations are thoroughly delineated, mapped, and protected from any foreseeable threats (addresses Factor A, D). (USFWS, 2019)

Recovery Priority Number: 1

Delisting Criteria:
Criterion 4. At least two (2) additional populations demonstrate a stable or increasing trend, evidenced by natural recruitment and multiple age classes; and, for at least one of these, the aquifer recharge area is protected by a conservation mechanism (addresses Factor A, D, E). Criterion 5. All other threats have been addressed or managed to the extent that the species will remain viable for the foreseeable future (addresses Factor A, D, E). (USFWS, 2019)

Recovery Actions:
- Study local and regional hydrological patterns [USFWS 1990]
- Conduct field surveys for Alabama cavefish [USFWS 1990]
- Assess and monitor the Key Cave aquifer [USFWS 1990]
- Assess and protect the energy source [USFWS 1990]
- Conduct biological studies of the entire Key Cave ecosystem [USFWS 1990]
- None developed; see Recovery Actions

- RECOMMENDATIONS FOR FUTURE ACTIONS 1. Characterize the hydrological functions and character (such as aquifer size and connectivity to other caves, sinkholes and entry points etc., time frame of water cycling through the system) of the recharge area for Key Cave. 2. Initiate traditional and exploratory survey methods for new populations of the species with environmental DNA survey technique and acoustic survey techniques. 3. Initiate real-time water monitoring for estimation of aquifer size and recharge rates. 4. Identify areas (up-gradient and within cave) for long-term monitoring stations to assess changes in groundwater quality and quantity. 5. Determine biological, hydrological and physical relationships between Key Cave, Collier Bone Cave, Persimmon, Thomason, Bell, Elbow and McKinney Pit caves. 6. Work with neighboring landowners on projects to protect groundwater and initiate water extraction conservation. 7. Determine and implement consistent sampling rates and intervals of all pools for the species. Determine connectivity and water flow through the pools. 8. Periodically analyze bat populations and bat guano for pesticides and other toxic residue. 10. Initiate selected long-term monitoring of the species and its habitat at sites within Key Cave pools. 11. Monitor impacts of NWR cooperative farming by monitoring chemical usages and testing groundwater for those chemicals (may be in conjunction with action 2). 12. Revise recovery plan to reflect new information, revise criteria, and continue implementation of other pertinent recovery actions from the recovery plan. 13. Develop an Alabama Cavefish Recovery Group (USFWS, 2017).

Conservation Measures and Best Management Practices:

- RECOMMENDED FUTURE ACTIVITIES A detailed discussion of recovery actions and criteria are presented in the Recovery Plan (Service 1990) and Alabama cavefish Recovery Plan amendment (Service 2019). During the course of this status review new and/or targeted potential recovery activities were identified and are included below. Recovery Activities 1. The species' recovery priority should be focused on establishing cooperative agreements with private landowners for the conservation of the species. The Key Cave recharge area is approximately 20 square miles in size and over 95% is in private ownership. 2. Management of Key Cave NWR habitats to improve recharge and conditions within Key Cave. a. Ensure the buffer around the entrance to Key Cave is protected from harmful agricultural practices in the area. b. Ensure pesticide use is minimized or not used at all near the cave entrance. Monitoring and Research Activities 1. Population monitoring should be conducted to assess the response of the Alabama cavefish to continued threats, determine the current population size, and determine other biological relationships within the Key Cave ecosystem that are currently unknown. 2. Continue water quality monitoring within Key Cave. 3. Additional studies should be conducted to determine if other populations of the Alabama cavefish exist in other locations or in other areas of Key Cave not yet explored. This could be accomplished utilizing traditional methods, eDNA monitoring, or other novel methods not yet considered. Continue support for the on-going research at a-number-of universities with faculty and graduate students conducting eDNA research on the Alabama cavefish as well as other subterranean species. 4. Additional studies of the recharge area should be conducted to get an updated understanding of current hydrological conditions and how groundwater impacts the Key Cave environment. 5. Consider gray bat monitoring to explore the relationships and benefits of a health bat population and nutrient levels within Key Cave and potential benefits to the Alabama cavefish. 6. Conduct biological studies of the entire Key Cave ecosystem (USFWS, 2023).

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SPECIES ACCOUNT: *Spirinchus thaleichthys* (Longfin smelt (San Franscisco Bay Delta DPS))

Species Taxonomic and Listing Information

Listing Status: Endangered

Physical Description

Longfin smelt measure 911 centimeters (cm) (3.54.3 inches (in)) standard length, although third-year females may grow up to 15 cm (5.9 in). The sides and lining of the gut cavity appear translucent silver, the back has an olive to iridescent pinkish hue, and mature males are usually darker in color than females. Longfin smelt can be distinguished from other smelts by their long pectoral fins, weak or absent striations on their opercular (covering the gills) bones, incomplete lateral line, low numbers of scales in the lateral series (54 to 65), long maxillary bones (in adults, these bones extend past mid-eye, just short of the posterior margin of the eye), and lower jaw extending anterior of the upper jaw (Mcallister 1963, p. 10; Miller and Lea 1972, pp. 158160; Moyle 2002, pp. 234236).

Taxonomy

In the 12-month finding published on April 2, 2012 (77 FR 19756), we determined that longfin smelt was not warranted for listing under the Act rangewide, but that the San Francisco Bay-Delta distinct population segment (Bay-Delta DPS) was warranted for listing, although listing was determined to be precluded by higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants. In this candidate species assessment, we focus on the Bay-Delta DPS; the reader is referred to the 2012 12-month finding for information on the status of the species rangewide. We have carefully reviewed the available taxonomic information to reach the conclusion that the longfin smelt (Spirinchus thaleichthys) is a valid taxon. The longfin smelt belongs to the true smelt family Osmeridae and is one of three species in the Spirinchus genus; the night smelt (Spirinchus starksi) also occurs in California, and the shishamo (Spirinchus lanceolatus) occurs in northern Japan (McAllister 1963, pp. 10, 15). Because of its distinctive physical characteristics, the Bay-Delta population of longfin smelt was once described as a species separate from more northern populations (Moyle 2002, p. 235). McAllister (1963, p. 12) merged the two species S. thaleichthys and S. dilatus because the difference in morphological characters represented a gradual change along the north-south distribution rather than a discrete set. Stanley et al. (1995, p. 395) found that individuals from the Bay-Delta population and Lake Washington population differed significantly in allele (proteins used as genetic markers) frequencies at several loci (gene locations), although the authors also stated that the overall genetic dissimilarity was within the range of other conspecific fish species. They concluded that longfin smelt from Lake Washington and the Bay-Delta are conspecific (of the same species) despite the large geographic separation. Delta smelt and longfin smelt hybrids have been observed in the Bay-Delta estuary (California Department of Fish and Game (CDFG) 2001, p. 473).

Historical Range

Longfin smelt have been observed in their winter and spring spawning period as far upstream as Isleton in the Sacramento River, Santa Clara shoal in the San Joaquin system, Hog Slough off the South-Fork Mokelumne River, and in Old River south of Indian Slough (CDFG 2009a, p. 7; Radtke

1966, pp. 115119). Lonfin smelt are distributed throughout the Bay-Delta including in Suisun Bay and Marsh, San Pablo Bay, and San Francisco Bay. Longfin smelt have also been found in the Napa and Petaluma Rivers (Merz 2013, p. 136). Longfin smelt also migrate out into the ocean including into the Gulf of Farallones to obtain food. In recent surveys, longfin smelt were captured in all major sloughs and tributary sloughs within the Alviso Marsh Complex salt pond restoration area in the South Delta (Hobbs 2012, pg. 39).

Current Range

The current distribution of longfin smelt in the Bay-Delta is similar to its historical distribution.

Distinct Population Segments Defined

Yes. San Francisco Bay-Delta Distinct Population Segment

Critical Habitat Designated

Yes;

Life History

Feeding Narrative

Adult: In the Bay-Delta, calanoid copepods such as Pseudodiatomus forbesi and Eurytemora sp., as well as the cyclopoid copepod Acanthocyclops vernali (no common names), are the primary prey of longfin smelt during the first few months of their lives (approximately January through May) (Slater 2009b, slide 45). Copepods are a type of zooplankton (organisms drifting in the water column of oceans, seas, and bodies of fresh water). The longfin smelts diet shifts to include mysids such as opossum shrimp (Neomysis mercedis) and other small crustaceans (Acanthomysis sp.) as soon as they are large enough (2030 mm (0.781.18 in)) to consume these larger prey items, sometime during the summer months of the first year of their lives (CDFG 2009, p. 12). Upstream of San Pablo Bay, mysids and amphipods form 80 to 95 percent or more of the juvenile longfin smelt diet by weight from July through September (Slater 2009, unpublished data). Longfin smelt occurrence is likely associated with the occurrence of their prey, and both of these invertebrate groups occur near the bottom of the water column during the day under clear water marine conditions.

Reproduction Narrative

Adult: Longfin smelt usually live for 2 years, spawn, and then die, although some individuals may spawn as 1- or 3-year-old fish before dying (Moyle 2002, p. 36). In the Bay-Delta, longfin smelt are believed to spawn primarily in freshwater in the lower reaches of the Sacramento River and San Joaquin River. Longfin smelt congregate in deep waters in the vicinity of the low salinity zone (LSZ) near X2 (see definition below) during the spawning period, and it is thought that they make short runs upstream, possibly at night, to spawn from these locations (CDFG 2009, p. 12; Rosenfield 2010, p. 8). The LSZ is the area where salinities range from 0.5 to 6 practical salinity units (psu) within the Bay-Delta (Kimmerer 1998, p. 1). Salinity in psu is determined by electrical conductivity of a solution, whereas salinity in parts per thousand (ppt) is determined as the weight of salts in a solution. For use in this document, the two measurements are essentially equivalent. X2 is defined as the distance in kilometers up the axis of the estuary (to the east) from the Golden Gate Bridge to the location where the daily average near-bottom salinity is 2 psu (Jassby et al. 1995, p. 274; Dege and Brown 2004, p. 51)). Longfin smelt in the Bay-Delta may spawn as early as November and as late as June, although spawning typically occurs from

January to April (CDFG 2009, p. 10; Moyle 2002, p. 36). Longfin smelt have been observed in their winter and spring spawning period as far upstream as Isleton in the Sacramento River, Santa Clara shoal in the San Joaquin system, Hog Slough off the South-Fork Mokelumne River, and in Old River south of Indian Slough (CDFG 2009a, p. 7; Radtke 1966, pp. 115119). Exact spawning locations in the Delta are unknown and may vary from year to year in location, depending onenvironmental conditions. However, it seems likely that spawning locations consist of the overlap of appropriate conditions of flow, temperature, and salinity with appropriate substrate (Rosenfield 2010, p. 8). Longfin smelt are known to spawn over sandy substrates in Lake Washington and likely prefer similar substrates for spawning in the Delta (Baxter et al. 2010, p. 62; Sibley and Brocksmith 1995, pp. 3274). Baxter found that female longfin smelt produced between 1,900 and 18,000 eggs, with fecundity greater in fish with greater lengths (CDFG 2009, p. 11). At 7°C (44.6°F), embryos hatch in 40 days (Dryfoos 1965, p. 42); however, incubation time decreases with increased water temperature. At 89.5°C (46.449.1 °F), embryos hatch at 29 days (Sibley and Brocksmith 1995, pp. 3274).

Geographic or Habitat Restraints or Barriers

Juvenile: Dams

Adult: Dams

Environmental Specificity

Juvenile: generalist

Adult: generalist

Dependency on Other Individuals or Species for Habitat

Juvenile: Not applicable

Adult: Not applicable

Habitat Narrative

Adult: The Bay-Delta is the largest estuary on the West Coast of the United States (Sommer et al. 2007, p. 271). The modern Bay-Delta bears only a superficial resemblance to the historical Bay-Delta. The Bay-Delta supports an estuary covering approximately 1,235 square kilometers (km^2) (477 square miles (mi^2)) (Rosenfield and Baxter 2007, p. 1577), which receives almost half of Californias runoff (Lehman 2004, p. 313). The historical island marshes surrounded by low natural levees are now intensively farmed and protected by large, manmade structures (Moyle 2002, p. 32). The watershed, which drains approximately 40 percent of the landarea of California, has been heavily altered by dams and diversions, and nonnative species now dominate, both in terms of numbers of species and numbers of individuals (Kimmerer 2004, pp. 79). The Bay Institute has estimated that intertidal wetlands in the Delta have been diked and leveed so extensively that approximately 95 percent of the 141,640 hectares (ha) (350,000 acres (ac)) of tidal wetlands that existed in 1850 are gone (The Bay Institute 1998, p. 17). The physical and biological characteristics of the estuary define longfin smelt habitat. The Bay-Delta is unique in that it contains significant amounts of tidal freshwater (34 km^2 (13 mi^2)) and mixing zone (194 km^2 (75 mi^2)) habitat (Monaco et al. 1992, pp. 254255, 258). San Francisco Bay is relatively shallow and consists of a northern bay that receives freshwater inflow from the Sacramento-San Joaquin system and a southern bay that receives little freshwater input (Largier

1996, p. 69). Dominant fish species are highly salt-tolerant and include the commercially important Pacific sardine (Sardinops sagax) and rockfish (Sebastes spp.). Major habitat types include riverine and tidal wetlands, mud flat, and salt marsh, with substantial areas of diked wetland managed for hunting. The sandy substrates that longfin smelt are presumed to use for spawning are abundant in the Delta. Longfin smelt are considered pelagic and anadromous (Moyle 2002, p. 236), although anadromy in longfin smelt is poorly understood, and certain populations are not anadromous and complete their entire life cycle in freshwater lakes and streams (see Lake Washington Population section below). Within the Bay-Delta, the term pelagic refers to organisms that occur in open water away from the bottom of the water column and away from the shore. Juvenile and adult longfin smelt have been found throughout the year in salinities ranging from pure freshwater to pure seawater, although once past the juvenile stage, they are typically collected in waters with salinities ranging from 14 to 28 parts per thousand (ppt) (Baxter 1999, pp. 189192). Longfin smelt are thought to be restricted by high water temperatures, generally greater than 22 degrees Celsius (C) (71 degrees Fahrenheit (°F)) (Baxter et. al. 2010, p. 68), and will move down the estuary (seaward) and into deeper water during the summer months, when water temperatures in the Bay-Delta are higher. Within the Bay-Delta, adult longfin smelt occupy water at temperatures from 16 to 20 C (61 to 68 F), with spawning occurring in water with temperatures from 5.6 to 14.5 C (41 to 58 F) (Wang 1986, pp. 69).

Dispersal/Migration

Motility/Mobility

Juvenile: Mobility limited

Adult: Mobile

Migratory vs Non-migratory vs Seasonal Movements

Juvenile: Migratory and non-migratory

Adult: Migratory and non-migratory

Dispersal

Juvenile: Moderate

Adult: Moderate

Immigration/Emigration

Juvenile: No

Adult: No

Dependency on Other Individuals or Species for Dispersal

Juvenile: Not applicable

Adult: Not applicable

Dispersal/Migration Narrative

Juvenile: Larval longfin smelt less than 12 millimeters (mm) (0.5 in) in length are buoyant because they have not yet developed an air bladder; as a result, they occupy the upper one-third of the water column. After hatching, they quickly make their way to the LSZ via river currents (CDFG 2009, p. 8; Baxter 2011a, pers. comm.). Longfin smelt develop an air bladder at approximately 12 to 15 mm (0.50.6 in.) in length and are able to migrate vertically in the water column. At this time, they shift habitat and begin living in the bottom two-thirds of the water column (CDFG 2009, p. 8; Baxter 2008, p. 1).

Adult: Longfin smelt are dispersed broadly in the Bay-Delta by high flows and currents, which facilitate transport of larvae and juveniles long distances. Longfin smelt larvae are dispersed farther downstream during high freshwater flows (Dege and Brown 2004, p. 59). They spend approximately 21 months of their 24-month life cycle in brackish or marine waters (Baxter 1999, pp. 214; Dege and Brown 2004, pp. 5860). In the Bay-Delta, most longfin smelt spend their first year in Suisun Bay and Marsh, although surveys conducted by the City of San Francisco collected some first-year longfin in coastal waters (Baxter 2011c, pers. comm.; City of San Francisco 1995, no pagination). The remainder of their life is spent in the San Francisco Bay or the Gulf of Farallones (Moyle 2008, p. 366; City of San Francisco 1995, no pagination). Rosenfield and Baxter (2007, pp. 1587, 1590) inferred based on monthly survey results that the majority of longfin smelt from the Bay-Delta were migrating out of the estuary after the first winter of their life cycle and returning during late fall to winter of their second year. They noted that migration out of the estuary into nearby coastal waters is consistent with captures of longfin smelt in the coastal waters of the Gulf of Farallones. It is possible that some longfin smelt may stay in the ocean and not re-enter freshwater to spawn until the end of their third year of life (Baxter 2011d, pers. comm.). Moyle (2010, p. 8) states that longfin smelt that migrate out of and back into the Bay-Delta estuary may primarily be feeding on the rich planktonic food supply in the Gulf of Farallones. Rosenfield and Baxter (2007, p. 1290) hypothesize that the movement of longfin smelt into the ocean or deeper water habitat in summer months is at least partly a behavioral response to warm water temperatures found during summer and early fall in the shallows of south San Francisco Bay and San Pablo Bay (Rosenfield and Baxter 2007, p. 1590).

Population Information and Trends

Population Trends:

Declining by 90 percent

Species Trends:

Significant declines

Resistance to Disease:

Little information is available on incidence of disease in the Bay-Delta longfin smelt DPS. Larval and juvenile longfin smelt were collected from the Bay-Delta in 2006 and 2007 and analyzed for signs of disease and parasites (Foott and Stone 2006, entire; Foott and Stone 2007, entire). No significant health problem was detected in either year (Foott and Stone 2007, p. 15). The south Delta is fed by water from the San Joaquin River, where pesticides (e.g., chlorpyrifos, carbofuran, and diazinon), salts (e.g., sodium sulfates), trace elements (boron and selenium), and high levels of total dissolved solids are prevalent due to agricultural runoff (64 FR 5963; February 8, 1999). Pesticides and other toxic chemicals may adversely affect the immune system of longfin smelt and other fish in the Bay-Delta and other estuaries, but we found no information documenting such effects.

Additional Population-level Information:

Conclusion for Discreteness: Because of its limited swimming capabilities and because of the great distances between the Bay-Delta and known breeding populations to the north, we conclude that the Bay-Delta population is markedly separated from other longfin smelt populations, and thus meets the discreteness element of the 1996 DPS policy. The best available information indicates that longfin smelt from the Bay-Delta population complete their life cycle moving between freshwater, brackish water, and saltwater portions of the estuary and nearby coastal ocean waters in the Gulf of Farallones. The nearest known breeding population of longfin smelt is Humboldt Bay, 420 km (260 mi) north of the Bay-Delta. As a result, potential interchange between the Bay-Delta population and other longfin smelt breeding populations is limited. Although the best scientific information suggests that potential movement of longfin smelt northward from the Bay-Delta would be facilitated by ocean currents, potential movement from more northern estuaries south to the Bay-Delta would be more difficult and unlikely because of ocean currents. Based on our review of the best available scientific and commercial information available, we conclude that the Bay-Delta population of longfin smelt is markedly separated from other longfin smelt populations as a consequence of physical, physiological, ecological, or behavioral factors.

Population Narrative:

Within the Bay-Delta, longfin smelt are consistently collected in the monitoring surveys that have been conducted by California Department of Fish and Wildlife ((CDFW) formerly CDFG) as far back as the late 1960s. Longfin smelt numbers in the Bay-Delta have declined significantly since the 1980s (Moyle 2002, p. 237; Rosenfield and Baxter 2007, p. 1590; Baxter et al. 2010, pp. 6164). Rosenfield and Baxter (2007, pp. 15771592) examined abundance trends in longfin smelt using three long-term data sets (19802004) and detected a significant decline in the Bay-Delta longfin smelt population. They confirmed the positive correlation between longfin smelt abundance and freshwater flow that had been previously documented by others (Stevens and Miller 1983, p. 432; Baxter et al. 1999, p. 185; Kimmerer 2002b, p. 47), noting that abundances of both adults and juveniles were significantly lower during the 1987-1994 drought than during either the pre- or post-drought periods (Rosenfield and Baxter 2007, pp. 1583-1584).

Threats and Stressors

Stressor: Reduced Freshwater Flow
Exposure:
Response:
Consequence:
Narrative: The primary threat to the Bay-Delta longfin smelt is reduced freshwater flows. In the Bay-Delta, freshwater flow is strongly related to the natural hydrologic cycles of drought and flood. Studies of Bay-Delta longfin smelt have found that increased Delta outflow during the winter and spring is the largest factor positively affecting longfin smelt abundance (Stevens and Miller 1983, pp. 431432; Jassby et al. 1995, p. 285; Sommer et al. 2007, p. 274; Thomson et al. 2010, pp. 14391440). During high outflow periods larvae are believed to benefit from increased transport and dispersal downstream, increased food production, reduced predation through increased turbidity, and reduced loss to entrainment due to a westward shift in the boundary of spawning habitat and strong downstream transport of larvae (CFDG 1992, pp. 45-61; Hieb and

Baxter 1993, pp. 106-107; CDFG 2009a, p. 18). Conversely, during low outflow periods, the negative effects of reduced transport and dispersal, reduced turbidity, and potentially increased loss of larvae to predation and increased loss at the export facilities result in lower young-of-the-year recruitment. Despite numerous studies of longfin smelt abundance and flow in the Bay-Delta, the underlying causal mechanisms are still not fully understood (Baxter et al. 2010, p. 69; Rosenfield 2010, p. 9). As Californias population has grown, demands for reliable water supplies and flood protection have grown. In response, State and Federal agencies built dams and canals, and captured water in reservoirs, to increase capacity for water storage and conveyance resulting in one of the largest manmade water systems in the world (Nichols et al. 1986, p. 569). Operation of this system has altered the seasonal pattern of freshwater flows in the watershed. Storage in the upper watershed of peak runoff and release of the captured water for irrigation and urban needs during subsequent low flow periods result in a broader, flatter hydrograph with less seasonal variability in freshwater flows into the estuary (Kimmerer 2004, p. 15). In addition to the system of dams and canals built throughout the Sacramento River-San Joaquin River basin, the Bay-Delta is unique in having a large water diversion system located within the estuary (Kimmerer 2002b, p. 1279). The State Water Project (SWP) and Central Valley Project (CVP) operate two water export facilities in the Delta (Sommer et al. 2007, p. 272). Project operation and management is dependent upon upstream water supply and export area demands. Despite the size of the water storage and diversion projects, much of the interannual variability in Delta hydrology is due to variability in precipitation from year to year. Annual inflow from the watershed to the Delta is strongly correlated to unimpaired flow (runoff that would hypothetically occur if upstream dams and diversions were not in existence), mainly due to the effects of high-flow events (Kimmerer 2004, p. 15). Water operations are regulated in part by the California State Water Resources Control Board (SWRCB) according to the Water Quality Control Plan (WQCP) (SWRCB 2000, entire). The WQCP limits Delta water exports in relation to Delta inflow (the Export/Inflow, or E/I ratio). It is important to note that in the case of the Bay-Delta, freshwater flow is expressed as both Delta inflow (from the rivers into the Delta) and as Delta outflow (from the Delta into the lower estuary), which are closely correlated, but not equivalent. Freshwater flow affects the location of the two-parts-per-thousand salinity isohaline (X2, indexed as distance in kilometers from the Golden Gate Bridge). The location of X2 is influenced by precipitation in the watershed (i.e., wetter or drier seasonal weather patterns) and by water operations both upstream at the dams and diversions, and in the Delta at the water export facilities (Jassby et al. 1995; Kimmerer 2004). Because X2 integrates many physical attributes over time and space, many Bay-Delta organisms respond to it, making it a useful indicator of habitat conditions (Jassby et al. 1995; Dege and Brown 2004). Along with seasonality and export volume, X2 may be an indicator of the risk of entrainment (Jassby et al. 1995; USFWS 2008; Grimaldo et al. 2009). In periods with greater freshwater flow into the Delta, X2 is pushed farther downstream (seaward); in periods with low flows, X2 is positioned farther landward (upstream) in the estuary and into the Delta. As flow reductions alter the position of X2 and the low-salinity zone moves upstream, longfin smelt must migrate farther upstream to obtain freshwater to spawn (CDFG 2009, p. 17). Longer migration distances into the Bay-Delta make longfin smelt more susceptible to entrainment in the State and Federal water pumps (see Factor E: Entrainment Losses, below). Not only is longfin smelt abundance in the Bay-Delta strongly correlated with Delta inflow and X2, but the spatial distribution of longfin smelt larvae is also strongly associated with X2 (Dege and Brown 2004, pp. 5860; Baxter et al. 2010, p. 61). As longfin hatch into larvae, they move from the areas where they are spawned and orient themselves just downstream of X2 (Dege and Brown 2004, pp. 58-60). Larval (winter-spring) habitat varies with outflow and with the location of X2 (CDFG 2009, p. 12), and has been reduced since the 1990s due to a general upstream shift in the location of X2 (Hilts 2012, unpublished data). The amount of rearing habitat (salinity between 0.1 and 18 ppt) is also presumed to vary with the location of X2 (Baxter et al. 2010, p. 64). However, as previously stated, the location of X2 is of particular importance to the distribution of newly-hatched larvae and spawning adults. The influence of water project operations from November through April, when spawning adults and newly-hatched larvae are oriented to X2, is greater in drier years than in wetter years (Knowles 2002, p. 7). In addition to the effects of reduced freshwater flow on habitat suitability for longfin smelt and other organisms in the Bay-Delta, one of the principal concerns over the biological impacts of these water export facilities has been entrainment of fish and other aquatic organisms.

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Our analyses under the Endangered Species Act include consideration of ongoing and projected changes in climate. The terms climate and climate change are defined by the Intergovernmental Panel on Climate Change (IPCC). The term climate refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007a, p. 78). The term climate change thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007a, p. 78). Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions. (For these and other examples, see IPCC 2007a, p. 30; and Solomon et al. 2007, pp. 3554, 8285). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is very likely (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007a, pp. 5-6 and figures SPM.3 and SPM.4; Solomon et al. 2007, pp. 2135). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities. Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (e.g., Meehl et al. 2007, entire; Ganguly et al. 2009, pp. 11555, 15558; Prinn et al. 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007a, pp. 4445; Meehl et al. 2007, pp. 760764 and 797811; Ganguly et

al. 2009, pp. 1555515558; Prinn et al. 2011, pp. 527, 529). (See IPCC 2007b, p. 8, for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation. Also see IPCC 2011(entire) for a summary of observations and projections of extreme climate events). Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 814, 1819). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (IPCC 2007a, p. 89; see also Glick et al. 2011, pp. 1922). There is no single method for conducting such analyses that applies to all situations (Glick et al. 2011, p. 3). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change. Global climate projections are informative, and, in some cases, the only or the best scientific information available for us to use. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (e.g., IPCC 2007a, pp. 812). Therefore, we use downscaled projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick et al. 2011, pp. 5861, for a discussion of downscaling). With regard to our analysis for the Bay-Delta longfin smelt DPS, downscaled projections are available.

Stressor: San Francisco Bay-Delta Climate Change
Exposure:
Response:
Consequence:
Narrative: Climate change may affect the Bay-Delta DPS of longfin smelt habitat as a result of (1) Changes in the timing and availability of freshwater flow into the estuary due to reduced snowpack and earlier melting of the snowpack; (2) sea level rise and saltwater intrusion into the estuary; (3) effects associated with increased water temperatures; and (4) effects related to changes in frequency and intensity of storms, floods, and droughts. It is difficult to evaluate effects related to changes in the timing and availability of freshwater flow into the estuary due to reduced snowpack and earlier melting of the snowpack because these potential effects will likely be impacted to some extent through decisions on water management in the intensively managed Sacramento River-San Joaquin River water basin. Continued sea level rise will result in saltwater intrusion and landward displacement of the low-salinity zone, which would likely negatively affect longfin smelt habitat suitability. Increasing water temperatures would likely affect distribution and movement patterns of longfin smelt in the estuary; longfin smelt may be displaced to locations with deeper and cooler water temperatures. This displacement may result in decreased survival and productivity. Increased frequency and severity of storms, floods, and droughts could result in reduced longfin smelt habitat suitability, but it is difficult to estimate these effects because of uncertainty about the frequency and severity of these events. However, warming may result in more precipitation falling as rain and less storage as snow, increasing winter runoff as spring runoff decreases (USBR 2011, p. 147). It is uncertain how a change in the timing and duration of freshwater flows will affect longfin smelt. Higher flows in January and February (peak spawning and hatching months) resulting from snow packs that melt sooner and

rain-on-snow events could potentially create better spawning and larval rearing conditions. This would reduce adult migration distance and increase areas of freshwater spawning habitat during these months. In addition, the higher turbidity associated with these flows may reduce predation on longfin smelt adults and larvae (Baxter 2011, pers. comm.). However, if high flows last only a short period, benefits may be negated by poorer conditions before and after the high flows. The National Academy of Sciences (NAS) projected that sea levels along the California coast south of Cape Mendocino will rise 430 centimeters (cm) (212 inches (in)) by 2030, 1261 cm (524 in) by 2050, and 42167 cm (1666 in) by 2100 (NAS 2012, p. 131) compared to 2000 sea levels. Research indicates that the coastal land area south of Cape Mendocino is sinking at an average rate of about 1 millimeter (mm) (.04 in) per year, although Global Positioning System (GPS)-measured rates vary widely (-3.70.6 mm per year) (NAS 2012, p. 93). The NAS committee used output from global ocean models under an IPCC (2007) mid-range greenhouse gas emission scenario (NAS 2012, p. 5). However, carbon dioxide emissions from fossil fuels for the past decade have been at the high end of IPCC scenarios owing to rapid economic growth in developing countries (Le Qu´er´e et al. 2009). Because emissions for the last decade have been on the high end of the IPCC scenarios, a maximum rise of 5.48 feet (ft) (167 cm) by 2100 is appropriate for analyzing the impact of sea level rise on longfin smelt. As the freshwater boundary and X2 move farther inland into the Delta with increasing sea level (see below) and reduced flows, adults will need to migrate farther into the Delta to spawn, increasing the risk of predation and the potential for entrainment into water export facilities and diversions for both themselves and their progeny.

Stressor: Channel Disturbances
Exposure:
Response:
Consequence:
Narrative: Channel maintenance dredging in the Bay-Delta is an ongoing periodic disturbance of longfin smelt habitat, but most activity occurs in areas where longfin smelt are not likely to be present. Dredging and other channel disturbances potentially degrade spawning habitat and cause entrainment loss of individual fish and eggs; disposal of dredge spoils also can create large sediment plumes that expose fish to gill-clogging sediments and possibly to decreased oxygen availability (Levine-Fricke 2004, p. 56). Longfin smelt is a pelagic species (living away from the bottom of the water column and shoreline), and thus less likely to be directly affected by dredging, sand and gravel mining, and other disturbances to the channel bed compared to bottom-dwelling fish species. Longfin smelt are likely most vulnerable to entrainment by dredging during spawning and egg incubation because eggs are deposited and develop on channel bottom substrates (CDFG 2009, p. 27). Egg development takes approximately 40 days (Moyle 2002, p. 236). Sand mining does occur in longfin smelt habitat, but has been reduced in recent years (Barnard 2012, S. 9) although this trend will likely not continue as demand for sand is partly controlled by road and other construction demands. Because spawning substrate is not limited for the species, loss of sand is not expected to result in a decline of the species. We have found no information documenting population impacts of dredging or sand and gravel mining on longfin smelt. Channel maintenance dredging occurs regularly within the Bay-Delta and other estuaries that serve as shipping channels (e.g., Humboldt Bay, Coos Bay, Yaquina Bay, Columbia River). In their 2009 status review on longfin smelt, CDFW concluded that effects of regular maintenance dredging and sand mining within the Bay-Delta estuary on longfin smelt were expected to be small and localized (CDFG 2009, p. 26). They reviewed two studies on entrainment effects of channel dredging, and each study found that no longfin smelt were entrained during dredging (fish that were entrained were primarily bottom-dwelling species).

Stressor: Inadequate regulations
Exposure:
Response:
Consequence:
Narrative: The continued decline in indices of longfin smelt abundance in the Bay-Delta suggest that existing regulatory mechanisms, as currently implemented, are not adequate to reduce threats to the species. Therefore, based on a review of the best scientific information available, we find existing regulatory mechanisms are either not sufficient or may not be addressing key threats to the species.

Stressor: Agricultural Diversions
Exposure:
Response:
Consequence:
Narrative: Water is diverted at numerous sites throughout the Bay-Delta for agricultural irrigation. Herren and Kawasaki (2001) reported over 2,200 such water diversions within the Delta, but CDFG (2009, p. 25) notes that number may be high because Herren and Kawasaki (2001) did not accurately distinguish intake siphons and pumps from discharge pipes. CALFED's Ecosystem Restoration Program (ERP) includes a program to screen remaining unscreened small agricultural diversions in the Delta and the Sacramento and San Joaquin Rivers. The purpose of screening fish diversions is to prevent entrainment losses; however, very little information is available on the efficacy of screening these diversions (Moyle and Israel 2005, p. 20). Agricultural operations begin to divert water in March and April, and many longfin smelt have begun leaving the Delta by this time. Water diversions are primarily located on the edge of channels and along river banks. Longfin smelt are a pelagic fish species and tend to occupy the middle of the channel and the middle of the water column, where they are unlikely to be vulnerable to entrainment into these diversions.

Stressor: Power Plants
Exposure:
Response:
Consequence:
Narrative: Two power plants located near the confluence of the Sacramento and San Joaquin Rivers, the Contra Costa Generating Station and the Pittsburg Generating Station, pose an entrainment risk to longfin smelt. Past entrainment losses of delta smelt at these two facilities were significant and considered a threat to delta smelt (75 FR 17671; April 7, 2010). Power plant operations have been substantially reduced since the late 1970s, when high entrainment and impingement were documented (CDFG 2009, p. 24); the power plants are now either kept offline or operating at very low levels, except as necessary to meet peak power needs. From 20072010, capacity utilization of these units averaged only 2.3 percent of maximum capacity. No longfin smelt were detected during impingement sampling conducted between May of 2010 and April of 2011 to monitor entrainment losses at the two power plants (Tenera Environmental 2011, entire). The company that owns the two power plants has retired one of the two power stations (Contra Costa Generating Station) (Hansen 2013, pers. comm.).

Stressor: Water Export Facilities
Exposure:

Response:
Consequence:
Narrative: The four State and Federal water export facilities (pumping stations) in the Delta are the State Water Project (SWP) facility in the south Delta, the Central Valley Project (CVP) in the south Delta, the Contra Costa facility in the south Delta, and the North Bay Aqueduct facility in the north Delta. The SWP and CVP facilities pump the majority of the water exported from the Delta. Average annual volumes of water exported from these facilities between 1995 and 2005 were 3.60 km3 at the SWP facility, 3.10 km3 at the CVP facility, 0.15 km3 at the Contra Costa facility, and 0.05 km3 at the North Bay Aqueduct facility (Sommer et al. 2007, p. 272). Depending on upstream flow through the Delta, operation of the SWP and CVP facilities often causes reverse flows in the river channels leading to them; longfin smelt that occupy these channels during certain times of the year may be entrained by these reverse flows. The SWP and CVP water export facilities are equipped with their own fish collection facilities that divert entrained fish into holding pens using louver-bypass systems to protect them from being killed in the pumps. The fish collected at the facilities are referred to as salvaged, and are loaded onto tanker trucks and returned to the western Delta downstream (Aasen 2009, p. 36). The movement of fish can result in mortality due to overcrowding in the tanks, stress, moving procedures, or predation at locations where the fish are released. Salvage is an index of entrainment, not an estimate, and is much smaller than total entrainment (Castillo et al. in review). Of spawning age fish (age-1 and age-2), which contribute most to longfin smelt population dynamics in the Bay-Delta, the total number of longfin smelt salvaged at both pumps between 1993 and 2007 was 1,133 (CDFG 2009, Attachment 3, p. 2). Fish entering the intake channel of the CVP or the radial gates of the 31,000-acre Clifton Court Forebay reservoir (SWP) are considered entrained (Fujimura 2009, p. 5; CDFG 2009b, p. 2). Most longfin smelt that become entrained in Clifton Court Forebay are unable to escape (CDFG 2009b, p. 4). The number of fish entrained at the SWP and CVP facilities has never been determined directly, but entrainment losses have been estimated indirectly using data from research and monitoring efforts. The magnitude of entrainment of larval longfin smelt is unknown because only fish greater than 20 mm in length are salvaged at the two facilities (Baxter et al. 2008, p. 21). In years with low freshwater flows, approximately half of the longfin smelt larvae and early juveniles may remain for weeks within the Sacramento-San Joaquin Delta (Dege and Brown 2004), where model simulations indicate they are vulnerable to entrainment into State Water Project, Central Valley Project, and other diversions (Kimmerer and Nobriga 2008, CDFG 2009a, p. 8).

Stressor: Entrainment Losses Due to Water Diversions
Exposure:
Response:
Consequence:
Narrative: Entrainment losses at the SWP and CVP water export facilities are a known source of mortality of longfin smelt and other pelagic fish species in the Bay Delta , although the full magnitude of entrainment losses and population-level implications of these losses have not been quantified. Elevated salvage of longfin smelt and other Bay-Delta pelagic fish between 2000 and 2005 corresponded with high volumes of water exports during winter (Baxter et al. 2010, p. 63). Baxter et al. (2010, p. 62) hypothesized that entrainment can impact the longfin smelt population during winter, particularly during years with low freshwater flows when a higher proportion of the population may spawn farther upstream in the Delta. However, Baxter et al. (2010, p. 63) conclude that these losses have yet to be placed in a population context, and no conclusions were drawn regarding their effects on recent longfin smelt abundance. CDFG (2009, p. 22)

believes that efforts to reduce past delta smelt entrainment loss through the implementation of the 2008 delta smelt biological opinion for SWP and CVP operations may have reduced longfin smelt entrainment losses, incidentally providing a benefit to the longfin smelt. These efforts to manage entrainment losses in drier years, when entrainment risk is greater, substantially reduce entrainment of longfin smelt of all life stages. Fujimura (2009) estimated cumulative longfin smelt entrainment at the SWP facility between 1993 and 2008 at 1,376,432 juveniles and 11,054 adults, and estimated that 97.6 percent of juveniles and 95 percent of adults entrained were lost. Fujimura (2009) estimated cumulative longfin entrainment at the CVP facility between 1993 and 2008 at 224,606 juveniles and 1,325 adults, and estimated that 85.2 percent of the juveniles and 82.1 percent of the adults entrained were lost showing that a large majority of salvage is unsuccessful. These estimated losses are 4 times higher than observed salvage at the CVP and 21 times higher than the actual salvage numbers at the SWP (Fujimura 2009, p. 2). The estimated entrainment numbers were much higher than the actual salvage numbers at the SWP, due in large part to the assumption that there are high pre-screen losses in the Clifton Court Forebay (CDFG 2009a, p. 21). It should be noted that these estimates were calculated using equations and parameters devised for other species and may not accurately estimate longfin smelt losses. Further, estimates may be misleading because the majority of estimated losses occurred during the dry year of 2002 (1.1 million juveniles estimated at the SWP) while during all other years estimated entrainment was below 70,000 individuals. Old and Middle river flow limits in the NMFS and USFWS Biological Opinions and the existing CESA regulations for longfin smelt have reduced longfin smelt entrainment losses. The comparatively high salvage that occurred in 2002 is unlikely to recur under the current Old and Middle river flow limits in the NMFS and USFWS Biological Opinions and the CESA regulations (see Factor D discussion, above). Longfin smelt congregate in deep waters in the vicinity of the low salinity zone (LSZ) near X2 during the spawning period, and it is thought that they make short runs upstream, possibly at night, to spawn from these locations (CDFG 2009, p. 12; Rosenfield 2010, p. 8). Adult longfin smelt can be entrained as a result of these spawning migrations; larvae and juveniles can be entrained when they rear in the Delta. Entrainment in the water export facilities in the Delta and losses are elevated during dry years when X2 is upstream and export volumes from the CVP and SWP pumps are high (Grimaldo et al. 2009, pp. 1260-1261, Rosenfield 2010, p. 19). However, the best available science suggests that the vast majority of longfin smelt do not spawn or rear in areas of the Delta (CDFW 2013, no pagination) where they or their progeny are in danger of entrainment in the majority of years and current regulations have likely reduced longfin smelt entrainment.

Stressor: Introduced Species
Exposure:
Response:
Consequence:
Narrative: In Suisun Bay, a key longfin smelt rearing area, phytoplankton biomass is influenced by the overbite or Amur River clam (Potamocorbula amurensis). A sharp decline in phytoplankton biomass occurred following the invasion of the estuary by this species, even though nutrients were not found to be limiting (Alpine and Cloern 1992, pp. 950951). Abundance of zooplankton decreased across several taxa, and peaks that formerly occurred in time and space were absent, reduced or relocated after 1987 (Kimmerer and Orsi 1996, p. 412). The general decline in phytoplankton and zooplankton is likely affecting longfin smelt by decreasing food supply for their prey species, such as opossum shrimp (Neomysis mercedis) (Kimmerer and Orsi 1996, pp. 418419). Models indicate that the longfin smelt abundance index has been on a steady linear decline since about the time of the invasion of the nonnative overbite clam in 1987 (Rosenfield

and Swanson 2010, p. 14). Given the observed negative association between the introduction of the overbite clam and longfin smelt abundance in the Bay-Delta and the documented decline of key longfin smelt prey items, we consider the current overbite clam population to be a threat to the Bay-Delta DPS of longfin smelt. Based on the observed associations in the Bay-Delta between overbite clam invasion and longfin abundance and the lack of effective control mechanisms, we expect the degree of this threat will continue into the foreseeable future. The Bay-Delta has numerous other invasive species that have disrupted ecosystem dynamics; however, only the overbite clam has been shown to have an impact on the longfin smelt population. We consider the overbite clam to be an ongoing threat to the Bay-Delta longfin smelt population.

Stressor: Contaminants
Exposure:
Response:
Consequence:
Narrative: In 2009, over 15 million pounds of pesticides were applied within the five-county Bay-Delta area and Bay-Delta waters are listed as impaired for several legacy and currently used pesticides under the Clean Water Act section 303(d) (California Department of Pesticide Regulation 2011, p. 1). Concentrations of dissolved pesticides vary in the Delta both temporally and spatially (Kuivila 2000, p. 1). Several areas of the Delta, particularly the San Joaquin River and its tributaries, are impaired due to elevated levels of diazinon and chlorpyrifos, which are toxic at low concentrations to some aquatic organisms (MacCoy et al. 1995, pp. 2130). Several studies have demonstrated the acute and chronic toxicity of two common dormant-spray insecticides, diazinon and esfenvalerate, in fish species (Barry et al. 1995, p. 273; Goodman et al. 1979, p. 479; Holdway et al.; 1994, p. 169; Scholz et al. 2000, p. 1911; Tanner and Knuth 1996, p. 244). Extensive research on the role of contaminants in the Pelagic Organism Decline is currently being conducted (Baxter et al. 2010, pp. 2836). Of potential concern are effects of high levels of mercury and other metals; high ammonium concentrations from municipal wastewater; potentially harmful cyanobacteria algal blooms; and pesticides, especially pyrethroid pesticides, which are heavily used in San Joaquin Valley agriculture. Contaminants may have direct toxic effects to longfin smelt and other pelagic fish and indirect effects as a result of impacts to prey abundance and composition. Ammonium has been shown to impact longfin smelt habitat by affecting primary production and prey abundance within the Bay-Delta (Dugdale et al. 2007, p. 26). While contaminants are suspected of playing a role in declines of pelagic fish species in the Bay-Delta (Baxter et al. 2010, p. 28), contaminant effects remain unresolved. Ammonia is un-ionized and has the chemical formula NH3. Ammonium is ionized and has the formula NH4+. The major factors determining the proportion of ammonia or ammonium in water are water pH and temperature. This is important, as NH3 ammonia is the form that can be directly toxic to aquatic organisms, and NH4+ ammonium is the form documented to interfere with uptake of nitrates by phytoplankton (Dugdale et al. 2007, p. 17; Jassby 2008, p. 3). In addition to direct effects on fish, ammonia in the form of ammonium has been shown to reduce primary production by inhibiting nitrate uptake and suppressing spring phytoplankton blooms in Suisun and Grizzly Bays (Dugdale et al. 2007, pp. 2628). The role of ammonium nitrogen uptake inhibition in Sacramento River primary production is less certain than in the Bays. Parker et al. (2012, pp. 577580) observed primary production in the Sacramento River decreased in the SRWTP region as compared to the upper river region during the months of March and April. However, a previous study found that chlorophyll declines above the SRWTP between the Tower Bridge in Sacramento and Garcia Bend (Foe et al. 2010, p. 13). The application of general ecological principles would lead us to believe that decreased primary productivity, wherever it occurs in longfin smelt habitat, is likely to lead

to a decrease in copepods and other zooplankton that longfin smelt rely upon for food. A link between primary productivity and productivity in higher trophic levels has been documented in various pelagic food webs (Nixon 1988, Sobczak et al. 2005), although it has not been shown specifically in the San Francisco Bay-Delta. Kimmerer 2008 (p. 24) showed a statistically significant relationship between juvenile delta smelt survival and zooplankton biomass over the long term. In summary, although no direct link has been made between contaminants and longfin smelt (Baxter et al. 2010, p. 68), ammonium has been shown to have a direct effect on the food supply that the Bay-Delta longfin smelt DPS relies upon. Therefore, we conclude that high ammonium concentrations may be a current and future threat to the Bay-Delta DPS of longfin smelt.

Recovery

Reclassification Criteria:
Not applicable

Delisting Criteria:
Not applicable

Recovery Actions:

- Increasing Delta outflows so that they more closely approximate unimpaired flows in the watershed would address several needs of the longfin smelt, likely improving habitat quality and quantity.
- Furthermore, increased winter and spring flows may reduce water clarity, which would increase habitat quality for longfin smelt. Contaminant reduction within the Bay-Delta could improve primary productivity while at the same time limiting toxicity exposure to longfin smelt.
- Reducing ammonia concentrations from the Sacramento Waste Water Treatment Plant may help to increase primary productivity within the Bay-Delta, resulting in better longfin smelt growth and survival.
- The reduction of pesticides entering the Delta could also improve habitat conditions.
- The CALFED Ecosystem Restoration Program (ERP) developed a strategic plan for implementing an ecosystem-based approach for achieving conservation targets (CALFED 2000a, pp. 13). The CDFW is the primary implementing agency for the ERP. The goal of ERP in improving conditions for longfin smelt will carry forward, irrespective of the species Federal listing status. CALFED had an explicit goal to balance the water supply program elements with the restoration of the Bay-Delta and tributary ecosystems and recovery of the longfin smelt and other species. Because achieving the diverse goals of the program is iterative and subject to annual funding by diverse agencies, the CALFED agencies have committed to maintaining balanced implementation of the program within an adaptive management framework. The intention of this framework is that the storage, conveyance, and levee program elements would be implemented in such a way that the longfin smelts status would be maintained and eventually improved.
- The Bay-Delta Conservation Plan (BDCP), an effort to help provide restoration of the Bay-Delta ecosystem and reliable water supplies, is currently in preparation by a collaborative effort between water agencies, resource agencies, and environmental groups. The BDCP is intended to provide a basis for permitting take of listed species under sections 7 and 10 of

the Act and the California Natural Communities Conservation Planning Act, and would provide a comprehensive habitat conservation and restoration plan for the Bay-Delta, as well as a new funding source. The BDCP shares many of the same goals outlined in the 2000 CALFED Record of Decision (CALFED 2000) but would not specifically address all listed-species issues. The BDCP would, however, target many of the threats to current and future listed species and could contribute to species recovery. However, the BDCP, if completed, would not be initiated until at least 2014 or later. The plans implementation is anticipated to extend through 2060.

Additional Threshold Information:

- Longfin smelt larvae can tolerate salinities of 26 psu within days of hatching, and can tolerate salinities up to 8 psu within weeks of hatching (Baxter 2011a, pers. comm.). However, very few larvae (individuals less than 20 mm in length) are found in salinities greater than 8 psu, and it takes almost 3 months for longfin smelt to reach juvenile stage. A fraction of juvenile longfin smelt individuals are believed to tolerate full marine salinities (greater than 8 psu) (Baxter 2011a, pers. comm.).
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References

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2014

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2015

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2016

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2017

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U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2019

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2020

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2021

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2022

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2023

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2024

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM 05/02/2025

SPECIES ACCOUNT: *Tiaroga cobitis* (Loach minnow)

Species Taxonomic and Listing Information

Listing Status: Endangered; February 23, 2012 (uplisted from Threatened); Southwest Region (R2)

Physical Description

The loach minnow is a small, slender fish less than 80 mm (3 in) in length. It is olivecolored overall, with black mottling or splotches. Breeding males have vivid red to red-orange markings on the bases of fins and adjacent body, on the mouth and lower head, and often on the abdomen (Minckley 1973, p. 134; Sublette et al. 1990, p. 186).

Taxonomy

The loach minnow is a member of the minnow family Cyprinidae. The loach minnow was first collected in 1851 from the San Pedro River in Arizona and was described by those specimens in 1865 by Girard (pp. 191–192).

Historical Range

The loach minnow was historically endemic to the Gila River Basin of Arizona, New Mexico, and Sonora, Mexico.

Current Range

U.S.: Arizona and New Mexico. Currently, the species persists in Arizona in the White River of Gila County, the North and East Forks of the White River in Navajo County, Aravaipa Creek in Graham and Pinal Counties, San Francisco and Blue Rivers and Campbell Blue Creek in Greenlee County. In New Mexico, the species could be found in the upper Gila River, including the East, Middle and West forks of Grant and Catron counties, the San Francisco and Tularosa Rivers in Catron County, and the lowermost Whitewater Creek and Dry Blue Creek in Catron County.

Distinct Population Segments Defined

No.

Critical Habitat Designated

Yes; 2/23/2012.

Legal Description

On February 23, 2012, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Tiaroga cobitis (Loach minnow) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes eight critical habitat units (CHUs) in Arizona and New Mexico (77 FR 10810-10932).

The critical habitat designation for Tiaroga cobitis includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Tiaroga cobitis.

Critical Habitat Designation

The critical habitat designation for Tiaroga cobitis includes eight CHUs in Apache, Cochise, Gila, Graham, Greenlee, Pinal, and Yavapai Counties, Arizona, and for Catron, Grant, and Hidalgo Counties, New Mexico (77 FR 10810-10932).

Unit 1: Verde River Subbasin, Yavapai County, Arizona. (i) Verde River for approximately 118.5 km (73.6 mi), extending from the confluence with Beaver and Wet Beaver Creek in Township 14 North, Range 5 East, southeast quarter of section 30 upstream to Sullivan Dam in Township 17 North, Range 2 West, northwest quarter of section 15. This mileage does not include the 1.2 km (0.8 mi) belonging to the Yavapai-Apache Nation, which is excluded from this designation. (ii) Granite Creek for approximately 3.2 km (2.0 mi), extending from the confluence with the Verde River in Township 17 North, Range 2 West, northeast quarter of section 14 upstream to a spring in Township 17 North, Range 2 West, southwest quarter of the southwest quarter of section 13. (iii) Oak Creek for approximately 54.3 km (33.7 mi), extending from the confluence with the Verde River in Township 15 North, Range 4 East, southeast quarter of section 20 upstream to the confluence with an unnamed tributary from the south in Township 17 North, Range 5 East, southeast quarter of the northeast quarter of section 24. (iv) Beaver Creek and Wet Beaver Creek for approximately 33.3 km (20.7 mi), extending from the confluence with the Verde River in Township 14 North, Range 5 East, southeast quarter of section 30 upstream to the confluence with Casner Canyon in Township 15 North, Range 6 East, northwest quarter of section 23. This mileage does not include the 0.2 km (0.1 mi) belonging to the Yavapai-Apache Nation, which is excluded from this designation. (v) Fossil Creek for approximately 22.2 km (13.8 mi) from its confluence with the Verde River at Township 11 North, Range 6 East, northeast quarter of section 25 upstream to the old Fossil Diversion Dam site at Township 12 North, Range 7 East, southeast quarter of section 14.

Unit 2: Salt River Subbasin, Apache and Gila Counties, Arizona. (i) East Fork Black River for approximately 19.1 km (11.9 mi) from the confluence with the West Fork Black River at Township 4 North, Range 28 East, southeast quarter of section 11 upstream to the confluence with an unnamed tributary approximately 0.82 km (0.51 mi) downstream of the Boneyard Creek confluence at Township 5 North, Range 29 East, northwest quarter of Section 5. (ii) North Fork East Fork Black River for approximately 7.1 km (4.4 mi) of the North Fork East Fork Black River extending from the confluence with East Fork Black River at Township 5 North, Range 29 East, northwest quarter of section 5 upstream to the confluence with an unnamed tributary at Township 6 North, Range 29 East, center of Section 30. (iii) Boneyard Creek for approximately 2.3 km (1.4 mi) extending from the confluence with the East Fork Black River at Township 5 North, Range 29 East, SW quarter of section 5 upstream to the confluence with an unnamed tributary at Township 6 North, Range 29 East, southeast quarter of section 32. (iv) Coyote Creek for approximately 3.4 km (2.1 mi) from the confluence with East Fork Black River at Township 5 North, Range 29 East, northeast quarter of section 8 upstream to an unnamed confluence at Township 5 North, Range 29 East, northwest quarter of section 10.

Unit 3: San Pedro River Subbasin, Cochise, Pinal, and Graham Counties, Arizona. (i) Aravaipa Creek for approximately 44.9 km (27.9 mi) extending from the confluence with the San Pedro River in Township 7 South, Range 16 East, center of section 9 upstream to the confluence with Stowe Gulch in Township 6 South, Range 19 East, southeast quarter of the northeast quarter of section 35. (ii) Deer Creek—3.7 km (2.3 mi) of the creek extending from the confluence with Aravaipa Creek at Township 6 South, Range 18 East, section 14 upstream to the boundary of the Aravaipa Wilderness at Township 6 South, range 19 East, section 18. (iii) Turkey Creek—4.3 km

(2.7 mi) of the creek extending from the confluence with Aravaipa Creek at Township 6 South, Range 19 East, section 19 upstream to the confluence with Oak Grove Canyon at Township 6 South, Range 19 east, section 32. (iv) Hot Springs Canyon for approximately 9.3 km (5.8 mi) extending from the confluence with Bass Canyon in Township 12 South, Range 20 East, northeast quarter of section 36 downstream to Township 12 South, Range 20 East, southeast quarter of section 32. (v) Redfield Canyon for approximately 6.5 km (4.0 mi) extending from Township 11 South, Range 19 East, northeast quarter of section 36 upstream to the confluence with Sycamore Canyon in Township 11 South, Range 20 East, northwest quarter of section 28. (vi) Bass Canyon for approximately 5.5 km (3.4 mi) from the confluence with Hot Springs Canyon in Township 12 South, Range 20 East, northeast quarter of section 36 upstream to the confluence with Pine Canyon in Township 12 South, Range 21 East, center of section 20.

Unit 4: Bonita Creek Subbasin, Graham County, Arizona. (i) Bonita Creek for approximately 23.8 km (14.8 mi) from the confluence with the Gila River in Township 6 South, Range 28 East, southeast quarter of section 21 upstream to the confluence with Martinez Wash in Township 4 South, Range 27 East, southeast quarter of section 27.

Unit 5: Eagle Creek Subbasin, Graham and Greenlee Counties, Arizona. (i) Eagle Creek for approximately 26.5 km (16.5 mi) from the Freeport-McMoRan diversion dam at Township 4 South, Range 28 East, southwest quarter of the northwest quarter of section 23 upstream to the confluence of East Eagle Creek in Township 2 North, Range 28 East, southwest quarter of section 20. This mileage does not include approximately 21.4 km (13.3 mi) of Eagle Creek on lands belonging to Freeport-McMoRan, which is excluded from this designation.

Unit 6: San Francisco River Subbasin, Greenlee County, Arizona and Catron County, New Mexico. (i) San Francisco River for approximately 189.5 km (117.7 mi) of the San Francisco River extending from the confluence with the Gila River in Township 5 South, Range 29 East, southeast quarter of section 21 upstream to the northern boundary of Township 6 South, Range 19 West, section 2. This mileage includes approximately 14.1 km (8.8 mi) of the San Francisco River on lands belonging to Freeport-McMoRan, which is excluded from this designation. (ii) Tularosa River for approximately 30.0 km (18.6 mi) from the confluence with the San Francisco River at Township 7 South, Range 19 West, southwest quarter of section 23 upstream to the town of Cruzville at Township 6 South, Range 18 West, southern boundary of section 1. (iii) Negrito Creek for approximately 6.8 km (4.2 mi) extending from the confluence with the Tularosa River at Township 7 South, Range 18 West, southwest quarter of the northwest quarter of section 19 upstream to the confluence with Cerco Canyon at Township 7 South, Range 18 West, west boundary of section 22. (iv) Whitewater Creek for approximately 1.9 km (1.2 mi) from the confluence with the San Francisco River at Township 11 South, Range 20 West, Section 27 upstream to the confluence with Little Whitewater Creek at Township 11 South, Range 20 West, southeast quarter of section 23.

Unit 7: Blue River Subbasin, Greenlee County, Arizona, and Catron County, New Mexico. (i) Blue River for approximately 81.4 km (50.6 mi) from the confluence with the San Francisco River at Township 2 South, Range 31 East, southeast quarter of section 31 upstream to the confluence of Campbell Blue and Dry Blue creeks at Township 7 South, Range 21 West, southeast quarter of section 6. (ii) Campbell Blue Creek for approximately 12.4 km (7.7 mi) from the confluence of Dry Blue and Campbell Blue Creeks at Township 7 South, Range 21 West, southeast quarter of section 6 to the confluence with Coleman Canyon in Township 4.5 North, Range 31 East, southwest quarter of the northeast quarter of section 32. (iii) Little Blue Creek for approximately 5.1 km (3.1 mi) from the confluence with the Blue River at Township 1 South, Range 31 East, center of section 5 upstream to the mouth of a canyon at Township 1 North, Range 31 East, northeast quarter of section 29. (iv) Pace Creek for approximately 1.2 km (0.8 mi) from the confluence with Dry Blue Creek at Township 6 South, Range 21 West, southwest quarter of section 28 upstream to a barrier falls at Township 6 South, Range 21 West, northeast quarter of section 29. (v) Frieborn Creek for approximately 1.8 km (1.1 mi) from the confluence with Dry Blue Creek at Township 7 South, Range 21 West, southwest quarter of the northwest quarter of section 5 upstream to an unnamed tributary flowing from the south in Township 7 South, Range 21 West, northeast quarter of the southwest quarter of section 8. (vi) Dry Blue Creek for approximately 4.7 km (3.0 mi) from the confluence with Campbell Blue Creek at Township 7 South, Range 21 West, southeast quarter of Section 6 upstream to the confluence with Pace Creek in Township 6 South, Range 21 West, southwest quarter of section 28.

Unit 8: Gila River Subbasin, Catron, Grant, and Hidalgo Counties, New Mexico. (i) Gila River for approximately 153.5 km (95.4 mi) from the confluence with Moore Canyon at Township 18 South, Range 21 West, southeast quarter of the southwest quarter of section 32 upstream to the confluence of the East and West Forks of the Gila River at Township 13 South, Range 13 West, center of section 8. This mileage does not include approximately 11.5 km (7.2 mi) of the Gila River on lands owned by Freeport-McMoRan, which is excluded from this designation. (ii) West Fork Gila River for approximately 13.0 km (8.1 mi) from the confluence with the East Fork Gila River at Township 13 South, Range 13 West, center of Section 8 upstream to the confluence with EE Canyon at Township 12 South, Range 14 West, east boundary of Section 21. (iii) Middle Fork Gila River for approximately 19.1 km (11.9 mi) of the Middle Fork Gila River extending from the confluence with West Fork Gila River at Township 12 South, Range 14 West, southwest quarter of section 25 upstream to the confluence of Brothers West Canyon in Township 11 South, Range 14 West, northeast quarter of section 33. (iv) East Fork Gila River for approximately 42.1 km (26.2 mi) extending from the confluence with West Fork Gila River at Township 13 South, Range 13 West, center of section 8 upstream to the confluence of Beaver and Taylor Creeks in Township 11 South, Range 12 West, northeast quarter of section 17. (v) Mangas Creek for approximately 1.2 km (0.8 mi) extending from Township 17 South, Range 17 West, at the eastern boundary of section 3 upstream to the confluence with Blacksmith Canyon at Township 17 South, Range 17 West, northwest quarter of section 3. This mileage does not include approximately 7.9 km (4.9 mi) of Mangas Creek on lands belonging to Freeport-McMoRan, which are excluded from the designation. (vi) Bear Creek for approximately 29.5 km (18.4 mi) extending from Township 15 South, Range 17 West, eastern boundary of section 33 upstream to the confluence with Sycamore and North Fork Walnut Creek at Township 16 South, Range 15 West, eastern boundary of section 15. This designation does not include approximately 1.9 km (1.2 mi) of Bear Creek on lands belonging to Freeport-McMoRan, which are excluded from this designation.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Tiaroga cobitis critical habitat consists of six components in Arizona and New Mexico (77 FR 10810-10932):

(1) Habitat to support all egg, larval, juvenile, and adult loach minnow. This habitat includes perennial flows with a stream depth of generally less than 1 m (3.3 ft), and with slow to swift flow velocities between 0 and 80 cm per second (0.0 and 31.5 in. per second). Appropriate

microhabitat types include pools, runs, riffles, and rapids over sand, gravel, cobble, and rubble substrates with low or moderate amounts of fine sediment and substrate embeddedness. Appropriate habitats have a low stream gradient of less than 2.5 percent and are at elevations below 2,500 m (8,202 ft). Water temperatures should be in the general range of 8.0 to 25.0 °C (46.4 to 77 °F).

(2) An abundant aquatic insect food base consisting of mayflies, true flies, black flies, caddis flies, stoneflies, and dragonflies.

(3) Streams with no or no more than low levels of pollutants.

(4) Perennial flows or interrupted stream courses that are periodically dewatered but that serve as connective corridors between occupied or seasonally occupied habitat and through which the species may move when the habitat is wetted.

(5) No nonnative aquatic species, or levels of nonnative aquatic species that are sufficiently low to allow persistence of loach minnow.

(6) Streams with a natural, unregulated flow regime that allows for periodic flooding or, if flows are modified or regulated, a flow regime that allows for adequate river functions, such as flows capable of transporting sediments.

(8) Areas that need special management or protection to insure razorback survival and recovery. These areas once met the habitat needs of the razorback sucker and may be recoverable with additional protection and management.

Special Management Considerations or Protections

When designating critical habitat, we assess whether the specific areas determined to be occupied at the time of listing contain the PBFs and may require special management considerations or protection. We believe each area included in these designations requires special management and protections as described in our unit descriptions. Special management considerations for each area will depend on the threats to the spikedace or loach minnow, or both, in that critical habitat area. For example, threats requiring special management include nonnative fish species and the continued spread of nonnative fishes into spikedace or loach minnow habitat. Other threats requiring special management include the threat of fire, retardant application during fire, and excessive ash and sediment following fire. Poor water quality and adequate quantities of water for all life stages of spikedace and loach minnow threaten these fish and may require special management actions or protections. Certain livestock grazing practices can be a threat to spikedace and loach minnow and their habitats, although concern for this threat has lessened due to improved management practices. The construction of water diversions can cause increasing water depth behind diversion structures, and has reduced or eliminated riffle habitat in many stream reaches. In addition, loach minnow are generally absent in stream reaches affected by impoundments. While the specific factor responsible for this is not known, it is likely related to modification of thermal regimes, habitat, food base, or discharge patterns. We have included below in our description of each of the critical habitat areas for the spikedace and loach minnow a discussion of the threats occurring in that area requiring special management or protections.

Life History

Feeding Narrative

Larvae: While adult loach minnows primarily consume mayfly nymphs throughout most of the year, larvae minnows consume true flies and mayflies as part of their primary diet (Propst et al. 1988 p. 27, Propst and Bestgen 1991 p. 35, USFWS 2012 p. 10835).

Juvenile: While adult loach minnows primarily consume mayfly nymphs throughout most of the year, juvenile minnows consume true flies and mayflies as part of their primary diet (Propst et al. 1988 p. 27, Propst and Bestgen 1991 p. 35, USFWS 2012 p. 10835).

Adult: Loach minnow are opportunistic, benthic insectivores that obtain their food from riffle-dwelling larval mayflies, black flies, and true flies, as well as from larvae of other aquatic insect groups such as caddisflies and stoneflies (USFWS 1991b). Loach minnow consume different prey items during their various life stages. Both larvae and juveniles primarily consume true flies; mayfly nymphs are also an important dietary element. The availability of pool and run habitats affects availability of prey species. Nonnative fishes have been introduced for a variety of reasons, resulting in interference or exploitive competition. Interference competition, such as predation, may result from interactions between loach minnow, nonnative channel, flathead catfish and red shiner.

Reproduction Narrative

Adult: Loach minnow will first spawn at age one in the spring when water temperatures range between 16-20°C (Propst et al. 1988 pp. 18-21, Propst and Bestgen 1991 p. 33, Gori et al. 2014 p. 247). Temperatures outside of this range may result in decreased or failed reproduction. Spawning is in the same riffles occupied by adults during the nonrepoductive season, where sex ratios appear approximately equal. Appropriate flow velocities, substrates, sediment levels, and riffle availability are important; loach minnow place eggs in areas with mean velocities ranging between 2.4 to 15.6 in/second (3.0 to 39.6 cm/second). Eggs are deposited on the underside of flattened rocks; cavities are usually open on the downstream side while the upstream portion of the rock is embedded in the substrate. The eggs have an adhesive quality to them. Males have been observed to guard cavities and eggs. Larvae apparently use low velocity nursery areas: 0-30 cm/sec, 3-30 cm deep, with sand, gravel, and cobble substrates and abundant instream cover (Sublette et al. 1990; Propst and Bestgen 1991; Federal Register, 8 March 1994). NatureServe 2015.

Geographic or Habitat Restraints or Barriers

Adult: Nonnative species; water temperatures <9°C; dams lacking a suitable fishway; high waterfalsl; upland habitats; impoundments.

Environmental Specificity

Adult: High

Tolerance Ranges/Thresholds

Adult: Loach minnow have a fairly narrow temperature tolerance with water temperatures in the range of 48.2 to 71.6 °F (9 to 22 °C).

Site Fidelity

Adult: High

Habitat Narrative

Egg: While embryonic loach minnows were found in the Gila River at depths that ranged between 3.0 and 30.5 cm, the majority of eggs, however, were found at depths that ranged between 6.1 and 21.3 cm (Propst et al. 1988 p. 37, USFWS 2012 p. 10836, Gori et al. 2014 p. 247). The shallow depths combined with the gravel to cobble substrate creates turbulent riffles that minimizes the accumalation of fine materials. Water flow is extremely important to the development of embryonic loach minnows. Moderate water flows keep embryos well oxygenated and ensure that fine sediment does not accrue within the interstitial spaces of the subtrate suffocating them. While water velocities can reach as high as 91.4 cm/sec, velocitiesof 42.7 cm/sec, or less, are typical where embronic loach minnow are found (Propst et al. 1988 pp. 36-37, Propst and Bestgen 1991 p. 32, USFWS 2012 p. 10836, Gori et al. 2014 p. 247). Research shows that slow water (< 5 cm/sec) can lead to dense fungal infections or mortality (Propst and Bestgen 1991 p. 34, Gori et al. 2014 p. 248). Loach minnows spawn in the same habitat that they normally occupy (USFWS 2012 p. 10836). As a result, embryonic loach minnows primarily occur on gravel to rubble substrate (Propst et al. 1988 p. 36, Propst and Bestgen 1991 p. 32). During spawning, the species attaches their adhesive eggs to the underside of smooth rocks that are elevated from the surface on the downstream side (Propst et al. 1988 pp. 21-24, Propst and Bestgen 1991 p. 34, USFWS 2012 p. 10832, 10835). Substrate should have low to moderate amounts of silt and embeddedness to ensure sufficient interstitial space exists for the deposition of eggs (USFWS 2012 p. 10834). The substrate provides the embryos with shelter from predators, excess siltation, and extreme water flows.

Larvae: While larval loach minnows were found at depths that ranged between 3.0 and 45.7 cm in the Gila River, they will typically use much shallower water along the stream margins that ranges between 3.0 and 15.2 cm deep (Propst et al. 1988 p. 37, Rinne 1991 p. 116, USFWS 2012 p. 10836). These shallow warm areas along the stream margins tend to have lower flow velocities that do not exceed the larvaes swim capabilities and are rich in food resources. Upon hatching, larval loach minnow move to shallow, perrenial water with lower water velocities (<20 cm/sec) than is found in the mainstem (Propst et al. 1988 p. 37, Propst and Bestgen 1991 p. 32, Rinne 1991 p. 116, USFWS 2012 p. 10832). This habitat usually occurs along the stream margins (USFWS 2012 p. 10836). Slower water flow allows the species to function without exceeding the larvae swim capability.

Juvenile: There is a slight seperation in depth between juvenile and adults in that adults are typically found between 12.2 and 27.4 cm, while juveniles are typically found between 9.1 and 24.4 cm (Propst et al. 1988 p. 37). A combination of shallow depth and rocky substrate create swift turbulent riffles that helps limit excess fine material allowing the species to shelter among the substrate. Juveniles can occupy habitat with a slighly wider range of water velocities than adults, most commonly between 35.1 and 85.3 cm/sec (Propst et al. 1988 p. 37, USFWS 2012 p. 10836).

Adult: Loach minnow is an obligate riffle-dweller, found in small to large perennial streams and use shallow, turbulent riffles with primarily cobble substrate and swift currents (Minckley 1973, p. 134; Propst et al. 1988, pp. 36– 43; Rinne 1989, pp. 113–115; Propst and Bestgen 1991, pp. 29, 32–33). The loach minnow is found in habitat with clean, loose gravel to cobble substrates that range in size from 16 to 256 mm (Propst et al. 1988 p. 36, Propst and Bestgen 1991 p. 32, Rinne 1991 pp. 113-115, USFWS 2012 p. 10811, 10832). The species lives, feeds, and spawns within the interstitial spaces of the substrate or in the lee of larger cobble (Rinne 1991 p. 115, USFWS 2012 p. 10832). The rough texture of gravel, cobble and rocks provides pockets of microhabitats with lower water velocities that allows the species to remain relatively stationary among the substrate expending less energy and remaining hidden from predators (Propst and Bestgen 1991 p. 36, USFWS 2012 p. 10833) The species is rare or absent from habitat where fine sediments fill the interstitial spaces in the substrate (Propst and Bestgen 1991 p. 34, USFWS 2012 p. 10811). It is rare or absent from habitats where fine sediments fill these interstitial spaces (Propst and Bestgen 1991, p. 34). Loach minnow have a fairly narrow temperature tolerance, and their upstream distributional limits in some areas may be linked to low winter temperature (Propst et al. 1988). Suitable temperature regimes appear to be fairly consistent across geographic areas with water temperatures in the range of 48.2 to 71.6 °F (9 to 22 °C) (Britt 1982, Leon 1989, Propst et al. 1988, Propst and Bestgen 1991, Vives and Minckley 1990). Adult and juvenile loach minnow primarily use shallow, turbulent riffles but may also be found in shallow runs and pools (USFWS 2012 p. 10832). Water depth in occupied habitat ranges between 6.1 - 45.7 cm deep (Propst et al. 1988 p. 37, Propst and Bestgen 1991 p. 32, Rinne 1991 pp. 113-115, USFWS 2012 pp. 10833). There is a slight seperation in depth between juvenile and adults in that adults are typically found between 12.2 and 27.4 cm, while juveniles are typically found between 9.1 and 24.4 cm (Propst et al. 1988 p. 37). A combination of shallow depth and rocky substrate create swift turbulent riffles that helps limit excess fine material allowing the species to shelter among the substrate. Loach minnows are found within small to large, low gradient (0.3-2.2%), perrenial streams where they tend to utilize habitats with moderately swift currents that can reach up to 80 cm/sec (Propst and Bestgen 1991 p. 32, Rinne 1991 pp. 113-115, USFWS 2012 p. 10811, 10832). The mean water velocity of occupied habitat is 52.6 cm/sec and relatively few minnows are found in water flowing < 15.2 cm (Propst et al. 1988 p. 37). Swift current aids in reducing the accumalation of fine material allowing the species to shelter among the substrate. Adult loach minnows are sometimes found in or near filamentous algae (USFWS 2012 p. 10832). It is believed that this association with filamentous algae may provide the species with cover protecting them from predation (USFWS 2012 p. 10835). Water with low levels of pollutants is essential for the maintenance of loach minnow. Loach minnow occur in areas where mining, agriculture, livestock operations, and road construction and use are prevalent. Various pollutants are associated with these types of activities. For loach minnow, waters should have low levels of pollutants such as copper, arsenic, mercury, and cadmium; human and animal waste products; pesticides; suspended sediments; and gasoline or diesel fuels (D. Baker, USFWS, pers. comm. 2005). In addition, dissolved oxygen should be greater than 3 ppm. Recurrent flooding is important in keeping substrate free of sediments and in helping this species maintain a competitive edge over invading nonnative fishes. Barriers to dispersal are dams lacking a suitable fishway; high waterfall; upland habitat. For some species (e.g., slender chub), an impoundment may constitute a dispersal barrier. For others (e.g., flame chub) a stream larger than 4th order may be a barrier.

Dispersal/Migration

Motility/Mobility

Adult: Low

Migratory vs Non-migratory vs Seasonal Movements

Adult: Non-migrant

Dispersal

Adult: Limited by unsuitable habitat

Immigration/Emigration

Adult: No

Dispersal/Migration Narrative

Adult: Data on dispersal and other movements generally are not available. In some species, individuals may migrate variable distances between spawning areas and nonspawning habitats. Barriers to dispersal are dams lacking a suitable fishway; high waterfall; upland habitat. For some species (e.g., slender chub), an impoundment may constitute a dispersal barrier. For others (e.g., flame chub) a stream larger than 4th order may be a barrier.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Population Growth Rate:

Unknown

Number of Populations:

6 to 20

Population Size:

Unknown

Minimum Viable Population Size:

Unknown

Resistance to Disease:

Unknown

Population Narrative:

Currently, only small, isolated populations remain, with limited to no opportunities for interchange between populations or expansion of existing areas, making the species more vulnerable to threats including reproductive isolation. Distribution and abundance probably have declined over the past 10 years or three generations. Data indicate that the population in New Mexico has declined in recent years (see USFWS 2012a). It is estimated that the present range is approximately 80 to 85 percent or less of the historical range (USFWS 2012b). This species is represented by 6 to 10 distinct occurrences (subpopulations) and locations (as defined by IUCN). Total adult population size is unknown. Abundance varies from common to very rare within occupied areas (USFWS 1999, 2012a). (NatureServe 2015). Occupied locations that are separated by a gap of 10 km or more of any aquatic habitat that is not known to be occupied represent different occurrences. An occupied habitat occurrence for a particular population does not artificially separate spawning areas and nonspawning areas as different occurrences simply because there have been no collections/observations in an intervening area that may exceed the separation distance.   When loach minnow was reclassified as endangered in 2012 (77 FR 10810), we determined that occupied streams included the White River mainstem, East Fork White River, North Fork East Fork Black River, Coyote Creek, Hot Springs Canyon, Aravaipa Creek, Deer Creek, Turkey Creek, Eagle Creek, the Blue River, and Campbell Blue Creek in Arizona, and Pace, Dry Blue, and Frieborn creeks, the San Francisco River, Tularosa River, Negrito Creek, Gila River mainstem, West, Middle, and East forks of the Gila River, and Mangas and Bear creeks in New Mexico. The status of loach minnow has improved in some of these areas and declined in others since reclassification. Extant populations. Since 2012, no new detections for loach minnow have occurred on the Verde River, Eagle Creek, North Fork Black River, or Coyote Creek, although traditional monitoring has occurred in both streams, as has environmental DNA (eDNA) monitoring for some streams (USFWS, 2023).

Threats and Stressors

Stressor: Prolonged drought (climate change)
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: While loach minnow have survived many droughts in their evolutionary histories, the present status of this species and its habitat are so degraded that the effects of the drought are more difficult for the species to withstand. In some areas of loach minnow habitat, drought results in lower streamflow, and consequently warmer water temperatures beyond the species tolerance limits, and more crowded habitats with higher levels of predation and competition. In other areas, drought reduces flooding, that would normally rejuvenate habitat and tend to reduce populations of some nonnative species, which are less adapted to the large floods of southwestern streams (Minckley and Meffe 1987, pp. 94, 104; Stefferud and Rinne 1996a, p. 80). The conjunction of drought with ongoing habitat loss and alteration; increased predation, competition, and disease from nonnative species; the uncertainties associated with climate change; and the general loss of resiliency in highly altered aquatic ecosystems have had negative consequences for loach minnow populations.

Stressor: Loss and degradation of habitat
Exposure: Not assessed; see narrative.
Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Impacts associated with roads and bridges, changes in water quality, and recreation have altered or destroyedmany of the rivers, streams, and watershed functions in the ranges of the loach minnow. Activities such as groundwater pumping, surface water diversions, impoundments, dams, channelization, improperly managed livestock grazing, wildfire, agriculture, mining, road building, residential development, and recreation all contribute to riparian habitat loss and degradation of aquatic resources in Arizona and New Mexico. Changes in flow regimes are expected to continue into the foreseeable future.

Stressor: Nonnative fishes
Exposure: Not assessed; see narrative.

Response: Not assessed; see narrative.
Consequence: Not assessed; see narrative.
Narrative: Competition with nonnative fish species is considered a primary threat to loach minnow. As with many fish in the West, loach minnow lacked exposure to a wider range of species, so that they seem to lack the competitive abilities and predator defenses developed by fishes from regions where more species are present (Moyle 1986, pp. 28–31; Douglas et al. 1994, pp. 9– 10). As a result, the native western fish fauna is significantly impacted by interactions with nonnative species. The introduction of more aggressive and competitive nonnative fish has led to significant losses of loach minnow (Douglas et al. 1994, pp. 14– 17). Loach minnow have been severely impacted by the presence of nonnative predators. Aquatic nonnative species have been introduced or spread into new areas through a variety of mechanisms, including intentional and accidental releases, sport stocking, aquaculture, aquarium releases, and bait-bucket release. Channel catfish, flathead catfish, and smallmouth bass appear to be the most prominent predators. In addition to threats from predation, loach minnow are likely to become impacted by parasites that have been documented in the Gila River basin and that are known to adversely affect or kill fish hosts.

Recovery

Reclassification Criteria:
Draft Recovery Plan Amendment: Downlisting Recovery Criteria 1. Remnant Populations. Maintain all 11 remnant populations of loach minnow in the wild at population levels identified in Table 1 (below) with trends of recruitment and population size indices considered stable or positive over the most recent rolling 10-year period. Conduct annual monitoring to document species persistence. 2. Replicate Populations. Within each Recovery Unit, the combination of remnant (Downlisting Criterion 1 above) and replicate populations must be three or more, as detailed in Table 1 (below). Because the recovery objective is to have the species persist without continual human management intervention, that total cannot include more than one refugia population. Replicates into new locations may require renovation to remove nonnative species that would compete with and prey on loach minnow. For wild populations, conduct annual monitoring to determine species are self-sustaining, as shown by persistence and reproduction, for five consecutive years following the last stocking effort at each site (USFWS, 2019).

Recovery Priority Number: 4C

Delisting Criteria:
Draft Recovery Plan Amendment: 1. Remnant Populations. Maintain all populations of loach minnow defined in Table 1 (above). Conduct annual monitoring to determine species are self-sustaining, as shown by persistence and reproduction, for five consecutive years following the last stocking effort at each site. 2. Additional Replicate Populations. Within RU1, RU2, and RU3, replicate additional populations of loach minnow into new, unoccupied areas of each respective RU, as detailed in Table 1 (above). Conduct annual monitoring to determine species are persisting, as shown by persistence and reproduction, for five consecutive years following each repatriation. . Replicates into new locations may first require habitat management actions to remove nonnative species that would compete with prey on loach minnow (USFWS, 2019).

Recovery Actions:

- Studies: (1) Updated genetic analyses to determine the status of the populations relative to one another; one study has been completed to date, and is now 20 years old (Tibbets 1993); (2) improved knowledge of habitat use to verify the suite of characteristics most essential to suitable habitat; information gathered would allow for better habitat renovation and site selection for future reintroduction projects, enhance our ability to analyze impacts from Federal activities, and recommend optimal minimization techniques
- Coordination: (1) Regular meetings with Tribal, private, and multi-agency partners to stay current on captive propagation, habitat restoration, monitoring, and repatriation projects; (2) completing revision of existing recovery plan, which should include adequate downlisting/delisting criteria, finalize a captive propagation plan, and prioritize reintroduction efforts.
- Management: 1. Complete the Verde River barrier and stream renovation and species reintroduction; 2. Re-evaluate the suitability of Bonita Creek and, if deemed suitable, complete renovation at Bonita Creek and ensure appropriate measures are enacted to minimize likelihood of subsequent reinvasion by nonnative species; 3. Revisit all potential areas through critical habitat redesignation analysis to ensure that all areas needed for survival and recovery are considered; 4. Work with Freeport McMoRan, the Apache-Sitgreaves National Forests, the San Carlos Tribe, the Arizona Game and Fish Department, and the Blue and Eagle Creek watershed group to assess the likelihood of renovating Eagle Creek; 5. Enhance captive propagation efficiency and/or duplicate the Bubbling Ponds Native Fish Conservation facility to minimize impacts on source populations while allowing for increased augmentation of introduced populations; 6. Minimize the spread of nonnative fishes; 7. Ensure adequate water supplies following appropriations through water settlements and losses due to drought or climate change through continued participation on appropriate interdisciplinary teams; 8. Complete additional stream renovations and species reintroductions, as determined Complete the Verde River barrier and stream renovation and species reintroduction; 9. Continue overseeing relevant section 7 consultations, developing minimization measures to improve or maintain habitat quality and following through on monitoring provisions and conservation measures; 10. Livestock grazing practices have been changed in many areas, minimizing or eliminating impacts in most loach minnow occupied streams, therefore visiting those areas under new management and determining what other stressors may need to be addressed, and whether further rehabilitation is required; 11. Develop emergency procedures for protection or evacuation of loach minnow from catastrophic wildfires or other events; 12. Work with parties to provide updated, relevant information on native fishes, including loach minnow; 13. Continue to implement translocations and reintroductions in New Mexico and Arizona.
- None developed; see Recovery Actions

Conservation Measures and Best Management Practices:

- RECOMMENDATIONS FOR FUTURE ACTIONS Many actions are occurring, as conducted by various partners engaged in loach minnow management and recovery. Additional recommendations for future actions include: • Complete the genetics management plan for the species, and use this plan to guide captive propagation and translocation efforts into the future; • Identify streams within the species' historical range with appropriate habitat characteristics, similar to Aravaipa Creek or the Tularosa River, where loach minnow can be translocated and prioritize native species management in these streams; • Develop a second hatchery in New Mexico to facilitate recovery efforts there; • Construct additional fish barriers where appropriate to continue species translocation and recovery efforts; • Pursue active management under the Watershed Management Plans in Arizona; •

Continue repatriation efforts at Hot Springs Canyon and Saliz Canyon (USFWS, 2023).

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SPECIES ACCOUNT: *Trogloglanis pattersoni* (Toothless blindcat)

Species Taxonomic and Listing Information

Listing Status: Proposed Endangered

Physical Description

A thorough understanding of the morphological variability of the toothless and widemouth blindcats is constrained by the few specimens collected and deposited in museum collections. Like other ictalurid species, blindcats lack scales and possess eight barbels (i.e., whisker-like sensory organs) arranged around the snout and mouth (Figures 1 and 2; Eigenmann 1919, p. 398; Hubbs and Bailey 1947, pp. 5, 10; Lundberg 1982, p. 16; Burr et al. 2020, p. 42). The toothless and widemouth blindcats appear to be among the smallest known ictalurids, reaching total lengths of up to 103.8 millimeters (mm) [4.1 inches (in)] and 136.9 mm (5.4 in), respectively (Hubbs and Bailey 1947, pp. 8–10, 12–14; Suttkus 1961, pp. 62–63; Lundberg 1982, pp. 10–11; Langecker and Longley 1993, p. 977; Burr et al. 2020, p. 26). Average size of collected toothless blindcats is 81. 2 mm (3.2 in) and 105 mm (4.1 in) for widemouth blindcats (Longley and Karnei 1978a, p. 43; 1978b, pp. 46, 49). A large toothless blindcat specimen (i.e., 87 mm [3.4 in]) weighed 16 grams (g) [0.6 ounces (oz)], with a large widemouth blindcat weighing 27 g (1.0 oz) [Karnei 1978, p. 79]. Neither species exhibits sexual dimorphism (USFWS, 2022)

Taxonomy

The toothless and widemouth blindcats are members of the catfish (Siluriformes) family Ictaluridae (Arce-H et al. 2017, pp. 406–407). Both species are the only members of their respective genera, Trogloglanis and Satan (Arce-H et al. 2017, pp. 406–407, 415). The toothless blindcat was described by Eigenmann (1919, pp. 397, 399–400) from a single individual collected, sometime prior to 1919, from an artesian well (i.e., George W. Brackenridge Well) in the City of San Antonio, Bexar County, Texas (Zara Environmental 2020, pp. 12, 14). A second specimen of that species was made available to researchers in the late 1930s (Hubbs and Bailey 1947, p. 1). That specimen was reportedly taken in 1934 from another artesian well (i.e., Josef Boecke Well) in or near the City of San Antonio (Hubbs and Bailey 1947, pp. 1–2; Zara Environmental 2020, pp. 12, 14). The toothless blindcat's initial description provided a very limited and general morphological description of the single specimen available at the time (Eigenmann 1919, pp. 399–400). Hubbs and Bailey (1947, pp. 11–14) redescribed the toothless blindcat with a much more robust and detailed assessment of the species' morphology. The widemouth blindcat was described by Hubbs and Bailey (1947, pp. 1, 4–11) from a single individual collected, sometime before 1938, from an artesian well (i.e., William Kempin Well) in the City of San Antonio (Zara Environmental 2020, pp. 12, 14). Examinations of these blindcat's phylogeny are restricted to morphological characters alone at present. Molecular investigations of blindcat genetics are either very limited or unavailable as chemical preservation methods applied in the past inhibit the ability of researchers to obtain usable genetic material (Zara Environmental 2010, pp. 21, 31–32; Lundberg et al. 2017, pp. 118– 119; Arce-H et al. 2017, p. 423; Zara Environmental 2020, p. 3). The most recent and comprehensive phylogenetic assessment of North American ictalurid species found that the toothless and widemouth blindcats, along with the Mexican blindcat (Prietella phreatophila) and Phantom blindcat (P. lundbergi), comprise a distinct clade (i.e., Troglobites) [Arce-H et al. 2017, pp. 415, 417–418, 422–423]. At minimum, the lineage of this clade is estimated to be 30–37 million years old (USFWS, 2022)

Current Range

The toothless and widemouth blindcats are endemic to a portion of the karstic Edwards Aquifer in Bexar County, Texas. An aquifer is a rock unit capable of storing and transmitting water (Ford and Williams 2007, p. 103; White 2012, p. 383). The term “karst” refers to a type of terrain and subsurface structures (e.g., caves and conduits) that are formed by the slow dissolution of calcium carbonate from surface and subsurface limestone, and other soluble rock types (e.g., carbonites and evaporates), by mildly acidic groundwater (Holsinger 1988, p. 148; Culver and Pipan 2009, pp. 5–15). Flow of groundwater through pores and along faults, and fractures leads to the formation of a system of interconnected subterranean conduits that become larger as bedrock is dissolved (Ford and Williams 2007, pp. 103–106, 112–114; Culver and Pipan 2009, pp. 5–8; Veni 2012, pp. 603–608; White 2012, pp. 383–386). Karst aquifers are typified by networks of conduits that can transport water relatively quickly over significant distances underground. All known specimens of the toothless and widemouth blindcats have been collected from groundwater wells along a southwest to northeast trending line through Bexar County, roughly paralleling the southeastern boundary of the aquifer’s artesian zone (Figure 6). To date, individuals of the toothless blindcat have been expelled from eight wells and the widemouth blindcat from five wells (Zara Environmental 2020, pp. 11–12; Diaz 2021, p. 30; Diaz et al. 2021, pp. 3; Diaz 2022b). The species co-occur at two wells. Wells that have produced either species tap subsurface Edwards Group Formations (Figure 7), ranging in depth from 308 m (1,010 ft) to 582 m (1,909 ft) (USFWS, 2022).

Critical Habitat Designated

No;

Life History

Food/Nutrient Resources

Food/Nutrient Narrative

Adult: Toothless blindcats are thought to be detritivores that feed on bacterial biofilms (USFWS< 2022).

Reproduction Narrative

Adult: Stygobiont fishes are generally characterized by increased age at first reproduction, lower numbers of reproductively active females, reduced numbers of eggs, slower growth rates, and longer life spans (Poulson 1963, pp. 266, 268, 275; Trajano 1997, p. 367; Trajano 2001, pp. 152–153; Trajano and Bichuette 2007, p. 114; Niemiller and Poulson 2010, pp. 220–227, 232–235; Secutti and Trajano 2021, p. 103). Stygobiont members of the family Amblyopsidae are among the world’s most studied subterranean fishes. The northern cavefish (Amblyopsis spelaea), Ozark cavefish (A. rosae), and southern cavefish (Typhlichthys subterraneus) have estimated lifespans of 30–45, 8–12, and 16–24 years of age, respectively (Niemiller and Poulson 2010, p. 226). Long lifespans have also been documented for some stygobiont catfish species (e.g., Ancistrus cryptophthalmus (i.e., 8–10 years), Ituglanis passensis (i.e., >10 years), and Trichomycterus itacarambiensis, [i.e., >10 years]) in Brazil (Trajano 1997, p. 367; Trajano 2001, pp. 151–152; Trajano and Bichuette 2007, p. 114; Secutti and Trajano 2021, p. 103). Female northern cavefish do not begin to reproduce until about six years of age (Niemiller and Poulson 2010, p. 221). Niemiller and Poulson (2010, pp. 221–222) estimated that a fraction of mature females produced offspring over a decade; 3% of northern cavefish, 13% of Ozark cavefish, and 7% of southern cavefish females. Females of this group produced fewer eggs than surface congeners (Poulson 1963, pp. 266, 268). Eggs of stygobiont amblyopsids are larger and more nutrient-rich, producing larger immatures than surface congeners (Niemiller and Poulson 2010, p. 224). Average clutch sizes of the northern cavefish (i.e., 65 eggs), Ozark cavefish (i.e., 34 eggs), and southern cavefish (i.e., 58 eggs) are generally small (Niemiller and Poulson 2010 pp. 225–226). Amblyopsids, and some stygobiont catfishes, reproduce seasonally in response to periods of increased nutrient availability (e.g., during periods of increased rainfall) [Poulson 1963, pp. 263– 264; Trajano 1991, p. 417; Niemiller and Poulson 2010, p. 221, 230–232; Secutti and Trajano 2021, p. 95]. A caveat to reproductive seasonality is that the best-studied stygobiont fishes are those that inhabit shallow subterranean systems that rely on direct input of nutrients from the surface (Trajano 1991, p. 417; Niemiller and Poulson 2010, pp. 183, 186, 230–232; Bichuette and Trajano 2021, p. 4; Secutti and Trajano 2021, p. 195). Non-seasonal breeding is seen in some stygobiont fish species (i.e., A. cryptophthalmus) (USFWS, 2022)

Habitat Type

Adult: subterranean groundwater

Habitat Narrative

Adult: Toothless and widemouth blindcats have never been directly observed in their natural subterranean habitat. The spatial configuration (i.e., height, length, and width) of preferred water-filled void space is not known. In general, physical space(s) used by these species likely consists of water-filled caves, fissures, fractures, and other voids of varying diameters (i.e., large enough to allow passage of juveniles and adults). The blindcats are anomalies among stygobiont fishes in terms of the great depths these fishes inhabit in groundwater-saturated strata (Trajano 2001, p. 140; Fišer et al. 2014, p. 976). Therefore, using other fishes as surrogates to ascribe physical habitat needs for the blindcats is tenuous at best. Most described stygobiont fish species have been recorded from shallower subterranean systems (e.g., humanly-accessible water-filled or flooded caves and underground streams) with more direct and immediate connections (e.g., cave entrance) to the surface (Noltie and Wicks 2001, pp. 177, 185–188; Romero and Paulson 2001, pp. 16–33; Trajano 2001, pp. 138–140; Romero et al. 2009, pp. 217–265). This includes Mexican and Phantom blindcats which primarily inhabit caves with surface entrances (Hendrickson et al. 2001, pp. 318–326). Those few stygobiont fishes (Monopterus roseni, Phreatichthys andruzzi, and Stygichthys lyphlops) known only from machine or hand-dug wells have also been taken from much shallower depths (e.g., < 30 m [< 98ft]) than blindcats (Romero and Paulson 2001, pp. 17–18, 23; Trajano 2001, p. 140; Fernández and de Pinna 2005, p. 105; Muriel-Cunha and de Pinna 2005, pp. 334–335; Shibatta et al. 2007, pp. 192–195; Fernández et al. 2007, pp. 53–56). The rock layers that comprise the Edwards Aquifer are extensively honey-combed and cavernous as a result of dissolution by groundwater (Livingston et al. 1936, pp. 72–73; Petitt and George 1956, p. 16; Maclay and Small 1986, p. 61). Faults, fissures, and fractures provide preferential flow paths for groundwater movement which facilitates the enlargement of those features, resulting in the development of interconnected solution channels (i.e., elongated voids in solid rock) and conduits (Livingston et al. 1936, pp. 72–73; Petitt and George 1956, p. 16; Lindgren et al. 2004, pp. 15, 21). Cavernous openings in deeper portions of the Edwards Aquifer have been observed during well-drilling activities. Borehole televiewers have provided images of cavernous openings and solutionally enlarged fractures (Hovorka et al. 2004, p. 8; Lindgren et al. 2004, p. 16). Such void space would likely provide the physical space required or used by toothless and widemouth blindcats (USFWS,

2022).

Dispersal/Migration

Dispersal/Migration Narrative

Adult: Subterranean dispersal corridors likely also exist for species inhabiting the karstic Edwards Aquifer. The Texas blind salamander (Eurycea rathbuni) is a federally endangered stygobiont salamander (32 FR 4001) known only from caves, springs, and wells in the Edwards Aquifer of southeastern Hays County, Texas. Dye-tracing has revealed that sites inhabited by that salamander are well-connected by groundwater flow paths (Johnson et al. 2012, pp. 8–10, 73– 79). Preliminary evaluation of Texas blind salamander genetic population structure suggests that sampled localities for this species are not reproductively isolated and interbreed (Chippindale 2009, pp. 8–9; Corbin 2020, p. 75). Though that salamander occupies a structurally different portion of the aquifer, the supposition that populations of aquatic stygobionts (i.e., invertebrates and vertebrates) can be interconnected is supported by research on other taxa (USFWS, 2022).

Population Information and Trends

Population Narrative:

No direct information is available on toothless and widemouth blindcat abundances or population sizes as their habitat is inaccessible to direct human sampling (e.g., mark-recapture or visual censuses). Even in accessible subterranean system, estimating population sizes of stygobiont fishes is notoriously difficult as some portion of their population(s) and/or habitat(s) is often unreachable by surveyors due to cave passage restrictions (Niemiller et al. 2013, p. 1,805; Trajano 2001, pp. 134–136). In humanly-accessible portions of caves, small population sizes have been recorded for the northern cavefish (e.g., 105 individuals; Poulson 1963, p. 269), Ozark cavefish (e.g., 100–200 individuals; Graening et al. 2010, p. 58), and southern cavefish (e.g., 41 individuals; Poulson 1963, p. 269). A survey of the Mexican blindcat found less than 100 individuals in humanly-accessible cave passages (Trajano 2001, p. 145). Population estimates have been developed for some stygobiont catfishes in shallow subterranean systems (e.g., cave streams) of Brazil (Table 5). These estimates suggest that populations of stygobiont catfishes can be large given sufficient physical habitat and food resources (Trajano 2001, pp. 141–142, 144–145; Bichuette and Trajano 2021, p. 10). Longley and Karnei (1978a, pp. 35–36; 1978b, pp. 36, 38–40) extrapolated their well survey data for the toothless and widemouth blindcats to calculate numbers of individuals ejected from wells in terms of well flow rates (i.e., catch per unit effort). For both species, those researchers assumed that fish were randomly exposed to capture by sampled wells and not clumped due to rate of water flow from those wells (Longley and Karnei 1978a, p. 35; 1978b, pp. 36, 38). For the Artesia Pump Station Well (Table 6), average flow at that well, over a 68-day sampling period in 1977, was 21,000 meters3 per day (m3 /day) [17 acre-feet (ac-ft)] with 22 specimens collected (Longley and Karnei 1978b, pp. 38, 54). Over that period, one toothless blindcat was ejected from the well with every 65,000 m3 (53 ac-ft) of water or one fish every 3.1 days (Longley and Karnei 1978b, p. 38). # sampling days/# specimens collected x average daily groundwater flow = catch per unit effort 68 days/22 specimens x 21,000 m3 /day (17 acre-feet (ac-ft) = 1 specimen per 65,000 m3 (53 ac-ft) At that flow rate, Longley and Karnei (1978b, p. 38) extrapolated that 118 toothless blindcats would be expelled from the Artesia Pump Station over 12 months of operation. Based on pumped flow records from 1950 to 1977, potential loss of toothless blindcats from this well was estimated at 3,256 individuals over that 28-year period (Longley and Karnei 1978b, p. 39). Similar estimations were developed for the widemouth blindcat at the Artesia Pump Station Well (Longley and Karnei 1978a, pp. 34–36). At the same flow rate of 21,000 m3 /day (17 ac-ft/day), with 11 specimens collected over 68 days, one widemouth blindcat was estimated to exit the well with every 129,515 m3 (105 ac-ft) of water or one fish every 6.2 days (Longley and Karnei 1978a, pp. 35, 48). Over 12 months, 59 widemouth blindcats would be ejected from the well (Longley and Karnei 1978a, p. 35). From 1950 to 1977, 1,628 widemouth blindcats would potentially have been expelled (Longley and Karnei 1978a, p. 36) (USFWS, 2022).

Threats and Stressors

Stressor: Mortality from Groundwater Wells
Exposure:
Response:
Consequence:
Narrative: As discussed in Section 6.0 Population and Species Needs, it is plausible that populations of the toothless and widemouth blindcats historically numbered in the tens of thousands of individuals. Prior to the advent of groundwater pumping, these fishes were only subject to demographic and environmental stochasticity such as predation, competition (e.g., starvation), and senescence with old age. The extraction of groundwater from the aquifer's artesian zone represented a new and nearly constant stressor impacting both species' populations. Well mortality is currently the most direct and observable anthropogenic agent of mortality for both species. In Bexar County, the drilling of wells to meet public supply and irrigation demands began in the late 1880s (Livingston et al. 1936, p. 87; Petitt and George 1956, p. 44). The advent of groundwater supplies to an area with limited surface water was a significant factor in the growth of the City of San Antonio (Figure 18; Arnow 1959, pp. 3; Richter 2013, pp. 347–349). By 1907, 100 artesian groundwater wells had been drilled in Bexar County, with 20 of those at depths of >300 m (>984 ft) [Taylor 1907, pp. 55–56)]. Over 1,500 wells had been drilled in Bexar County by 1953, with 250 wells being large capacity (i.e., 25–76 centimeters (cm) [10–30 in] in diameter) [Petitt and George 1956, p. 44; Maclay 1995, p. 43]. San Antonio Public Service Company Well 4 (i.e., Well 164), drilled in 1942, discharged groundwater at a rate of 156,664,295 m3 (27,010 ac-ft) per year (Petitt and George 1956, p. 47). Additional large capacity wells, with outputs ranging from 11,705,743 m3 (9,490 ac-ft) to 29,714,577 m3 (24,090 ac-ft), were drilled during the 1950s across the City of San Antonio and Bexar County (Petitt and George 1956, p. 47; Arnow 1959, pp. 24, 29) (USFWS, 2022).

Stressor: Climate Change
Exposure:
Response:
Consequence:
Narrative: Anthropogenic climate change has the potential to impact quantity of groundwater in the San Antonio segment (Green et al. 2011, pp. 538–546; Kløve et al. 2014, pp. 252–253, 258; Wuebbles et al. 2017, p. 14; Wineland et al. 2021, pp. 8–10). The Edwards Aquifer is considered among Texas' most vulnerable aquifers to climate change due to its dependence on precipitation for recharge and very rapid response to decreased or increased recharge (Loáiciga et al. 2000, pp. 192–193; Mace and Wade 2008, pp. 658, 662, 664–665; Loáiciga and Schofield 2019, p. 236; Ding and McCarl 2020, p. 11). Reduced precipitation during dry periods is known to result in lower water levels in the Edwards Aquifer (Arnow 1959, pp. 21–24, 27–29). Changing climatic

conditions, coupled with groundwater pumping, could lead to greater declines in aquifer water levels (Arnow 1959, pp. 21–24; Buszka 1987, pp. 24–27; Lindgren et al. 2004, p. 40). Between 1901 and 2016, annual average air temperature in the United States increased by 1.0 °C (1.8 °F), with temperatures expected to rise by 1.4 °C (2.5 °F) between 2021 and 2050 (Wuebbles et al. 2017, p. 17). Much greater temperature increases are projected into 2100 (Wuebbles et al. 2017, p. 17). Annual average air temperatures in the southern Great Plains, including Texas, are projected to increase by 2.0–2.8 °C (3.6–5.1 °F) by the mid-21st century (Kloesel et al. 2018, p. 995). Periods of extreme heat are expected to be more frequent, with number of days exceeding 38 °C (100 °F) increasing by an additional 30–60 days per year by the end of the 21st century (National Oceanic and Atmospheric Administration 2022, pp. 1-5; Kloesel et. al. 2018, pp. 990, 996). Downscaled climate projections for Bexar County were obtained from the U.S. Climate Resilience Toolkit (U.S. Federal Government, 2021). From 2022 to 2099, projections indicate that average daily maximum temperature will increase in that county from 28.3 °C (83 °F) in 2022 to 30 °C (86 °F) by 2099 under both high (Representative Concentration Pathway [RCP] 8.5) and low emissions (RCP 4.5). The average daily minimum temperature is projected to increase from 14.9 °C (58.9 °F) in 2022 to 19.2 °C (66.5 °F) in 2099 with high emissions and from 14.9 °C (58.9 °F) in 2022 to 16.7 °C (62 °F) under low emissions. Number of days per year above 40.5 °C (105 °F) in Bexar County are projected to increase from 2.3 days in 2022 to 52 days in 2099 with high emissions and from 4 days in 2022 to 13 days under low emissions. Average annual precipitation is not projected to change as markedly under high or low emission scenarios.

Stressor: Groundwater Contamination
Exposure:
Response:
Consequence:
Narrative: Contamination of groundwater by inorganic and organic substances has been identified as one of the primary stressors to stygobiont fishes globally (Proudlove 2021, pp. 202–203; Bichuette and Trajano 2010, pp. 68–70; Niemiller et al. 2013, p. 1,809). Karst aquifers are especially vulnerable to contamination given the high porosity and permeability of those systems which can rapidly transport groundwater over long distances (Kaçaroğlu 1999, pp. 340–343; Clark 2000, pp. 1–2; Vesper et al. 2003, pp. 1–2; Bichuette and Trajano 2010, pp. 68–70; Opsahl et al. 2018, p. 3; Mahler and Musgrove 2019, pp. 245–246; Guerra and Debbage 2021, p. 2). Surface water (e.g., precipitation, run-off, and streamflow) recharging karst aquifers is often focused to specific entry points (e.g., caves, fractures, and sinkholes) that provide little opportunity for filtration of dissolved and solid contaminants (Leibundgut 1998, pp. 46–47, 59; Kaçaroğlu 1999, pp. 337– 338, 340–342, 344–345). Anthropogenic contaminants can be introduced in several ways including 1) leaks from landfills, pipelines, petroleum storage tanks, septic tanks, and sewer lines, 2) spills of hazardous materials along roadways or railways and from petroleum extraction activities, 3) releases of untreated wastewater, and 4) land surface run-off from agricultural fields, impervious cover, and livestock operations (Vesper et al. 2003, p. 2; Johnson et al. 2009, p. 44; Burri et al. 2019, pp. 142–145). Abandoned water and petroleum wells that intersect aquifer formations represent another potential source of groundwater contamination. Contamination events may be acute, occurring over a few hours or days, or chronic, taking place over years to decades (Proudlove 2001, pp. 202–203; Niemiller et al. 2013, pp. 1,813–1,814). Major human activities that generate contaminants are agriculture (e.g., animal waste, fertilizers, herbicides, and pesticides), industry (e.g., hydrocarbons), and waste management (e.g., septic tanks and sewage) [Vesper et al. 2003, pp. 2–10; Burri et al. 2019, pp. 142–145; Li et al. 2021, pp. 2–4]. Common inorganic contaminants are nitrogen (e.g., ammonia,

nitrate, and nitrite), phosphorus, and heavy metals (e.g., zinc, mercury, and cadmium) [Burri et al. 2019, pp. 144– 145; Li et al. 2021, p. 3]. There are also hundreds of organic materials that can contaminate groundwater such as atrazine, benzene, chloroform, tetrachloroethene, and trichloroethene.

Recovery

Conservation Measures and Best Management Practices:

-

Additional Threshold Information:

-
-

References

USFWS. 2022. Species Status Assessment for the Toothless Blindcat (Trogloglanis pattersoni) and Widemouth Blindcat (Satan eurystomus). Version 2.0 November 1, 2022. Austin, TX. 120 pp + Appendices.

SPECIES ACCOUNT: *Xyrauchen texanus* (Razorback sucker)

Species Taxonomic and Listing Information

Listing Status: Endangered. Recommend downlisting to Threatened (USFWS, 2018)

Physical Description

Also known as the humpback sucker, the adult razorback sucker is readily identifiable by the abrupt sharp-edged dorsal keel behind its head and a large fleshy subterminal mouth that is typical of most suckers. Adult fish are relatively robust, often exceeding 3 kg (6 lbs.) in weight and 600 mm (2 ft.) in length. Although traces of the developing keel have been observed externally on some cultured specimens as small as 85 mm (3.3 in.) (Snyder and Muth 1990), the dorsal keel of juvenile razorback suckers may not be obvious in other individuals, making them difficult to distinguish from other sucker species.

Taxonomy

The razorback sucker was described by Abbott (1881) from a single mounted specimen captured from the Colorado River. He placed it in the genus Catostomus, but Eigenmann and Kirsch, after further study, assigned it to its own genus, Xyrauchen (Kirsch 1889).

Historical Range

The razorback sucker was once abundant throughout 5,835 kin (3.500 ml.) of the Colorado River basin, primarily in the mainstein and major tributaries in Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming and in the States of Baja California Norte and Sonora of Mexico (Ellis 1914, Minckley 1973). The Colorado River was divided into upper and lower basins at Lee Ferry, Arizona (approximately 14 km (9 ml.) below Glen Canyon Dam), by the Colorado River Compactof 1922. There are many accounts of razorback suckers during early settlement of the lower basin (Gilbert and Scofleld 1898, Minckley 1973) and a significant commercial fishery for them existed in southern Arizona in the early 1900's (Hubbs andMiller 1953, Miller 1964). In the upper basin, Jordan (1891) reported razorback suckers to be very abundant at Green River, Utah, in 1889. Residents living along the Colorado River near Clifton, Colorado, observed several thousand razorback suckers during spring runoff in the 1930's and early 1940's (account in Osmundson and Kaeding 1989a).

Current Range

The razorback sucker distribution has been reduced to about 1,208 km (750 mi.) in the upper basin (McAda and Wydoski 1980, Flolden andStalnaker 1975, Ecology Consultants 1978). In the lower basin a substantial population exists only in Lake Mohave, but they do occur upstream in Lake Mead and the Grand Canyon and downstream sporadically on the mainstem and associated impoundments and canals (Marsh and Minckley 1989). Marsh and Minckley (in press) estimated approximately 60,000 adult razorback suckers still occur in Lake Mohave, and Lanigan and Tyus (1989) estimated that 758 to 1,138 razorback suckers still inhabit the upper GreenRiver. In the upper Colorado River subbasin most razorback suckers occur in the Grand Valley area (Valdez et al. 1982). Observations in other areas are spotty and inconsistent and are generally viewed as incidental captures. The number of adult captures in the Grand Valley had declined appreciably since 1975 (Osmundson and Kaeding 1991). No significant recruitment to any population has been documented in recent years (Tyus 1987a. McCarthy and Minckley 1987, Osmundson and Kaeding 1989).

Distinct Population Segments Defined

No

Critical Habitat Designated

Yes; 3/21/1994.

Legal Description

On March 21, 1994, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Xyrauchen texanus (Razorback sucker) under the Endangered Species Act of 1973, as amended (Act). The critical habitat designation includes fifteen critical habitat units (CHUs) in Arizona, California, Colorado, Nevada, New Mexico and Utah (59 FR 13374-13400).
The critical habitat designation for Xyrauchen texanus includes areas that were determined by the Service to be occupied at the time of listing, that contain the primary constituent elements essential for the conservation of the species, and that may require special management or protection. The Service determined that no additional areas were essential to the conservation of Xyrauchen texanus.

Critical Habitat Designation

The critical habitat designation for Xyrauchen texanus includes fifteen CHUs in Coconino, Graham, Greenlee, Gila, Pinal, Yavapai, La Paz, Yuma and Mohave Counties, Arizona; San Bernardino. Riverside, and Imperial Counties, California; Delta, Garfield, Mesa and Moffat Counties, Colorado; Uintah, Carbon, Garfield, Grand, Emery, Wayne and San Juan Counties, Utah; Clark County, Nevada; and San Juan County, New Mexico (59 FR 13374-13400).

Unit 1—Colorado: Moffat County. The Yampa River and its 100-year flood plain from the mouth of Cross Mountain Canyon in T.6N., R.98W., sec. 23 (6th Principal Meridian) to the confluence with the Green River in T.7N., R.103W., sec. 28 (6th Principal Meridian).

Unit 2—Utah: Uintah County; and Colorado: Moffat County. The Green River and its 100-year flood plain from the confluence with the Yampa River in T.7N., R.103W., sec. 28 (6th Principal Meridian) to Sand Wash in T.11S., R.18E., sec. 20 (6th Principal Meridian).

Unit 3—Utah: Uintah, Carbon, Grand, Emery. Wayne, and San Juan Counties. The Green River and its 100-year flood plain from Sand Wash at T.11S., R.18E., sec. 20 (6th Principal Meridian) to the confluence with the Colorado River in T.30S., R.19E., sec. 7 (6th Principal Meridian).

Unit 4—Utah: Uintah County. The White River and its 100-year flood plain from the boundary of the Uintah and Ouray Indian Reservation at river mile 18 in T.9S., R.22E., sec. 21 (Salt Lake Meridian) to the confluence with the Green River in T.9S., R.20E., sec. 4 (Salt Lake Meridian).

Unit 5—Utah: Uintah County. The Duchesne River and its 100-year flood plain from river mile 2.5 in T.4S., R.3E., sec. 30 (Salt Lake Meridian) to the confluence with the Green River in T.5S., R.3E., sec. 5 (Uintah Meridian).

Unit 6—Colorado: Delta and Mesa Counties. The Gunnison River and its 100-year flood plain from the confluence with the Uncompahgre River in T.15S., R.96W., sec. 11 (6th Principal Meridian) to Redlands Diversion Dam inT.1S., R.IW., sec. 27 (Ute Meridian).

Unit 7—Colorado: Mesa and Garfield Counties. The Colorado River and its 100-year flood plain from Colorado River Bridge at exit 90 north off Interstate 70 inT.6S., R.93W., sec. 16 (6th Principal Meridian) to Westwater Canyon in T.20S., R.25E., sec. 12 (Salt Lake Meridian) including the Gunnison River and its 100-year flood plain from the Redlands Diversion Dam in T.1S., R.1W., sec. 27 (Ute Meridian) to the confluence with the Colorado River in T.1S., R.1W., sec. 22 (Ute Meridian).

Unit 8—Utah: Grand, San Juan, Wayne, and Garfield Counties. The Colorado River and its 100-year flood plain from Westwater Canyon in T.20S., R.25E., sec. 12 (Salt Lake Meridian) to full pool elevation, upstream of North Wash and including the Dirty Devil arm of Lake Powell inT.33S., R.14E., sec. 29 (Salt Lake Meridian).

Unit 9—New Mexico: San Juan County; and Utah: San Juan County. The San Juan River and its 100-year flood plain from the Hogback Diversion in T.29N., R.16W., sec. 9 (New Mexico Meridian) to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T.41S., R11E., sec. 26 (Salt Lake Meridian).

Unit 10—Arizona: Coconino and Mohave Counties; and Nevada: Clark County. The Colorado River and its 100-year flood plain from the confluence with the Paria River in T.40N, R.7E., sec. 24 (Gila and Salt River Meridian) to Hoover Dam in T.30N., R.23W., sec. 3 (Gila and Salt River Meridian) including Lake Mead to the full pool elevation.

Unit 11—Arizona: Mohave County and Nevada: Clark County. The Colorado River and its 100-year flood plain from Hoover Dam in T.30N., R.23W.., sec. 1 (Gila and Salt River Meridian) to Davis Darn in T.21N.., R21W., sec. 18 (Gus and Salt River Meridian) including Lake Mohave to the full pool elevation.

Unit 12—Arizona: La Paz and Yuma Counties; and California: San Bernardino. Riverside, and Imperial Counties. The Colorado River and its 100-year flood plain from Parker Darn in T.11N., R18W., sec. 16 (Gila and Salt River Meridian) to imperial Dam in T.6S., R22W., sec. 25 (Gila and Salt River Meridian) including Imperial Reservoir to the full pool elevation or 100-year flood plain, whichever is greater.

Unit 13—Arizona: Graham, Greenlee, Gila, and Pinal Counties. The Gila River and its 100-yearflood plain from the Arizona-New Mexico border in T8S, R32E., sec. 34 (Gila and Salt River Meridian) to Coolidge Darn in T.3S., R.18E, sec. 17 (Gila and Salt River Meridian), including San Carlos Reservoir to the full pool elevation.

Unit 14—Arizona: Gila County. The Salt River and its 100-year flood plain from the old U.S. Highway 60/State Route 77 bridge (unsurveyed) to Roosevelt Diversion Dam in T.3N., R14E., sec. 4 (Gila and Salt River Meridian).

Unit 15—Arizona: Yavapai County. The Verde River and its 100-yearflood plain from the U.S. Forest Service boundary (Prescott National Forest} in T.18N., R.2E, sec. 31 to Horseshoe Dam in T.7N., R.ZE. sec. 2 (Gila and Salt River Meridian). including Horseshoe Lake to the full pool elevation.

Primary Constituent Elements/Physical or Biological Features

Primary constituent elements (PCEs) are the physical and biological features of critical habitat essential to a species' conservation. The PCEs of Xyrauchen texanus critical habitat consists of eight components in Arizona, California, Colorado, Utah and New Mexico (59 FR 13374-13400):

(1) Water: This includes a quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, lack of contaminants, nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for the particular life stage for each species.

(2) Physical Habitat: This includes areas of the Colorado River system that are inhabited or potentially habitable by fish for use in spawning, nursery, feeding, and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100- year flood plain, which when inundated provide spawning, nursery, feeding and rearing habitats, or access to these habitats.

(3) Biological Environment: Food supply, predation, and competition are important elements of the biological environment and are considered components of this constituent element. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although considered normal components of this environment, are out of balance due to introduced nonnative fish species in many areas.

(4) Presence of known or suspected wild spawning populations, although recruitment may be limited or nonexistent.

(5) Areas where juvenile razorback suckers have been collected or which could provide suitable nursery habitat (backwaters, flooded bottom lands, or coves).

(6) Areas presently occupied or that were historically occupied that are considered necessary for recovery and that have the potential for reestablishment of razorback suckers.

(7) Areas and water required to maintain range-wide fish distribution and diversity under a variety of physical, chemical, and biological conditions.

(8) Areas that need special management or protection to insure razorback survival and recovery. These areas once met the habitat needs of the razorback sucker and may be recoverable with additional protection and management.

Life History

Feeding Narrative

Larvae: Diets of razorback sucker larvae have been studied in Lake Mohave (Marsh and Langhorst 1988) and under experimental conditions (Papoulis 1988, Tyus and Severson 1990). Larvae from reservoirs selected Bosmjna spp. (Cladocera) and avoided Copepoda, while larvae from backwaters or Lake Mahave selected Bosmincr and avoided Rotifera (Marsh and Langhorst 1988). Dietary studies in controlled conditions indicated wide differences in their response to commercial fish foods (Tyus and Severson 1990). Information is not available on food habits of razorback sucker larvae from natural riverine habitats.

Adult: Only limited information has been accumulated on the food habits of adult razorback suckers, primarily due to their rarity and protected status under State law. Marsh (1987) examined the stomachs of 34 adult specimens from Lake Mohave and found contents dominated by planktonic crustaceans, diatoms, filamentous algae, and detritus. Jonez and Sumner (1954) reported midge larvae as the dominant food item in theirstomach analysis of Lake Mohave razorback suckers. They also reported algae as the most common food item found in razorback sucker stomachs from Lake Mead, followed by plankton, insects, and decaying organic matter. Vanicek (1967) examined eight adult razorback sucker stomachs from the Green River and found them packed with mud or clay containing chironomid larvae, plant stems and leaves. Using scales, Minckley (1983) estimated annual growth rates in the wild Lake Mohave population to be less than 10 mm (0.4 in.) per year after their seventh year of life. Recently, researchers have demonstrated the inadequacies of using scales to determine the age of razorback suckers and have shown that most razorback suckers captured in recent times are much older than their scales would indicate (McCarthy and Minckley 1987). Using sectioned otoliths, McCarthy and Minckley (1987) computed the ages of Lake Mohave razorback suckers collected in 1981—83 to be 24 to 44 years. Eighty-nine percent of the 70 fish sampled were estimated to have hatched prior to or coincident with impoundment. Disappearance of razorback suckers from lower basin reservoirs 40 to 50 years after impoundment was documented by Minckley (1983). McCarthy and Minckley (1987) predicted the Lake Mohave population is following this trend and may be extirpated before the year 2000. Tyus (1987a concluded that razorback suckers in the Green River were substantially smaller and younger than those found in the lower basin, but no recent recruitment to the adult population was evident.

Reproduction Narrative

Adult: Some adult razorback suckers migrate considerable distances to specific areas to spawn (Tyus 1987a, Tyus and Karp 1990). Spawning occurs in the lower basin from January through April (Ulmer 1980, Langhorst and Marsh 1986, Mueller 1989). In the upper basin, ripe razorback suckers were observed in suspected spawning areas in the Green River from April 20 to June 14, from 1981 to 1989 (Tyus 1987a, Tyus and Karp 1990). Osmundson and Kaeding (1991) summarized captures by various investigators of razorback suckers in the Grand Valley, and reports that 40 of the 42 running ripe adults captured were captured between May 24 and June 17. Water temperatures during spawning in the lower basin ranged from 11.5—18°C (52.7-4.4°F)(Douglas 1952. Ulmer 1980. Langhorst and Marsh 1986) while temperatures recorded in the upper Green River ranged from 9—17°C(48.-63°F)(Tyus and Karp 1990). Spawning isusually accomplished overgravel bars that are swept free of silt by currents and several males accompany a single female (Jonez and Sumner 1954. Uliner 1980). In Lake Mohave and Senator Wash Reservoir. spawning takes place on gravelbars swept clean by wave action (Ulnier 1980, Bozek et al. 1984). Tyus (1987a) collected ripe adults over coarse sand substrates and in the vicinity of gravel or cobble bars, but direct observation of spawning was not possible because of high turbidities prevalent during that time of year. In Senator Wash Reservoir and Lake Mohave. The eggs apparently settled onto gravel and into interstices swept clean by the spawning activity; larvae remained in the gravel until swim-up (Uliner 1980, Mueller 1989).Anumber of investigators have collected viable fertilized eggs and larvae in the areas of observed spawning activity (Bozek et al. 1984, Ulmer 1980, Marsh and Langhorst 1988,Tyus 1987a), but few have collected larvae larger than 14 mm (0.8 in.) in the wild. This indicates little or no successful recruitment of wild razorback suckers (Tyus 1987a). Marsh andLanghorst (1988) recovered larvae up to 20 mm (0.8 in.) total length in an isolated backwater in Lake Mohave where predators had been previously eradicated, and growth to 20 cm (7.9 in.) was reported for juvenile razorback suckers in the same location (Minckley et aL in press). However, these fish disappeared within a month following reinvasion of the backwater bypredators. Most investigators have reported concentrations of carp (Cyprinus carpio), green sunfish (Leponils cvanelius), bluegill (Lepornis mocrochirus), channel catfish (Ictaluruspunctatus), and largemouth bass (Micropterus salnioides) in razorback sucker spawning areas (Jonez andSumner 1954, Marsh and Langhorst 1988, Ulmer 1980, Bozek et al. 1984). Larvaeand larger razorback suckers have been found in stomachs of predatory fishes such as green sunfish, warmouth (Lepornis gulosus), channel catfish, flathead catfish (Pylodictis olivaris),and threadfin shad (Dorosorna petenense) (Marsh and Langhorst 1988. Langhorst 1989, Brooks 1986).

Geographic or Habitat Restraints or Barriers

Larvae: impoundments

Spatial Arrangements of the Population

Larvae: clumped according to suitable habitat

Juvenile: clumped according to suitable habitat

Adult: clumped according to suitable habitat

Environmental Specificity

Larvae: generalist

Juvenile: generalist

Adult: generalist

Tolerance Ranges/Thresholds

Larvae: unknown

Juvenile: unknown

Adult: unknown

Dependency on Other Individuals or Species for Habitat

Larvae: not applicable

Juvenile: not applicable

Adult: not applicable

Habitat Narrative

Larvae: Habitat needs of young and juvenile razorback suckers in the wild are largely unknown because they rarely have been encountered by researchers, particularly in native riverine habitats (Tyus 1987a). Marsh and Langhorst (1988) observed that larval razorback suckers in Lake Mohave remained near shore after hatching but either disappeared or migrated to depths in excess of 15 m (49 ft.) within a few weeks. Most juveniles have been collected from irrigation canals in southern California and Arizona (Marsh and Minckley 1989). Substantial numbers of razorback suckers have been reared through the juvenile and adult stages in hatcheries (Toney 1974, Harnman 1985) and in isolated ponds (Langhorst 1989).

Adult: Adult razorback suckers are more vulnerable to capture during the fall spawning season. Tyus (1987b) reported them to be 10 times more prevalent in standardized electrofishing collections during the spring than during the remainder of the year. During spawning season, razorback suckers have been found in runs with coarse sand, gravel, and cobble substrate; flooded bottomlands and gravel pits; and large eddies formed by flooded mouths of tributary streams and drainage ditches (Tyus 1987a. Osmuñdson and Kaeding 1989a). Tyus (1987a) tracked six radioimplanted adult razorback suckers for 2 years. and found that they utilized the main channel of the Green and Duchesne Rivers. During non-breeding season, the fish were found in depths of 0.6 to 3.4 m (2.0 to 11.0 ft.), used sand or silt substrates, and water velocities of 0.1 to 0.6 m per second (0.33 to 2.0 ft. per second). Razorback suckers also selected near shore runs during the spring, but shifted to relatively shallow waters off mid-channel sandbars during the summermonths. Except for spawning migrations, razorback suckers are fairly sedentary, moving relatively few kilometers over several months (Tyus 1987a, Tyus and Karp 1990). Valdez and Masslich (1989) tracked 17 razorback suckers throughout the winter on the Green River. They found that most of the radio-telemetered fish moved less than 5 km (3 mi.) throughout the winter. They also reported localized diel movement patterns that increased with fluctuating flows which they attributed to changes in water velocities. The radio-telemetered razorback suckers used slow run habitats, slack waters, and eddies. They selected depths of 0.6 to 1.4 m (2.0 to 4.6 ft.) and velocities of 0.03 to 0.33 m per second (0.1 to 1.1 ft. per second). Osmundson and Kaeding (1989a) reported the year round movement and habitat use of one to four radio-telemetered adult razorback suckers over a 3-year period in the Grand Valley region of the upper Colorado River. They reported that pools and slow eddy habitats were predominantly used from November through April, runs arid pools from July through October, runs and backwaters during May, and backwaters and flooded gravel pits during June. Selection of habitats of various depths changed seasonally: use of relatively shallow water occurred during spring and use of deep water during winter. Mean depths were 0.9 to 0.99 m (3.0—3.3 ft.) during May and June, 1.62 to 1.65 rn(5.3—5.4 ft.) from August through September, and 1.83 to 2.18 m (6.0—7.1 ft.) from November through April.

Dispersal/Migration

Motility/Mobility

Larvae: moderate

Juvenile: high

Adult: high

Migratory vs Non-migratory vs Seasonal Movements

Larvae: not migratory

Juvenile: not migratory

Adult: not migratory

Immigration/Emigration

Larvae: unlikely

Juvenile: unlikely

Adult: unlikely

Dependency on Other Individuals or Species for Dispersal

Larvae: not applicable

Juvenile: not applicable

Adult: not applicable

Dispersal/Migration Narrative

Adult: Razorback suckers migrate long distances to spawn, but their migration is impeded by dams.

Population Information and Trends

Population Trends:

Declining

Species Trends:

Declining

Resiliency:

'When all habitat and demographic conditions were averaged for each population (Table EX1 and EX2), population resiliency is classified as medium (scores of 1.51 to 2.25) for all populations with the exception of the Colorado River below Parker dam, which was categorized as low (between 0.76 and 1.5)' (USFWS, 2018). 'When only demographic conditions for each population are averaged to represent resiliency, one population is in high condition (3), one population is in medium condition (2), five are in low condition (1) and one is in extirpated condition (0) (USFWS, 2018a).

Representation:

Genetic representation both within and among populations is high, but genetic adaptability will remain low as long as stocking is required to maintain populations as adaptive genetic traits are not passed from one generation to another through natural recruitment (USFWS, 2018a).

Redundancy:

Razorback sucker are widely distributed across the Colorado River basin, occurring in multiple habitat types and likely to withstand local or even regional catastrophes. The high genetic diversity present in Lake Mohave is distributed throughout the lower basin through larval collections and subsequent stocking, providing redundancy (USFWS, 2018a).

Population Growth Rate:
unknown

Number of Populations:
1 to 20

Population Size:
2500 to 10,000 individuals

Minimum Viable Population Size:
unknown

Resistance to Disease:
unknown

Adaptability:
low

Population Narrative:
Of great concern is the fact that significant recruitment of young fish to these populations has not been evident for at least 30 years. There is considerable evidence that existing populations are composed primarily of old individuals that are slowly dying off (McCarthy and Minckley, 1987, Tyus 1987a). Only a few naturally reproduced juveniles have been reported from Lake Mohave, the Colorado River, and offstreamcanal systems downstream of Lake Mohave (Marsh and Minckley 1989) and from the Green River (Holden 1978) in the past 15 years.

Threats and Stressors

Stressor: Dams
Exposure: Not assessed
Response: Not assessed
Consequence: Not assessed
Narrative: Since 1910, 15 dams have been constructed on the lower Colorado River and its major tributaries, the Gila, Verde, and Salt Rivers. These dams have dewatered, cooled, or impounded most of the lower basin system so that little natural riverine habitat exists today. Glen Canyon Dam has reduced water temperatures for 384 km (238 mi.) through the Grand Canyon. Spawning has been observed in several reservoirs in the lower basin (Jones and Sumner 1954, Loadermilk 1985) and razorback sucker larvae have been collected in Lake Mohave, Lake Havasu, Senator Wash Reservoir, and the Central Arizona Project canal (Bozek et al. 1984. Marsh and Langhorst 1988. Marsh and Minckley 1989). In the upper basin, Lake Powell and Flaming Gorge Reservoir have impounded 500 km (310 mi.) of razorback sucker habitat and lowered watertemperatures in another 106 km (65 mi.) of the Colorado and Green Rivers. Other upper basin reservoirs also have altered natural flow and temperature regimes. Dams and diversions also obstruct razorback sucker migration. Although little is known of the location of razorback sucker spawning areas prior to the construction of these facilities, it is believed that they have obstructed access to or impounded once important spawning areas. Early investigators frequently referred to spawning concentrations in small tributaries in the lower basin (Jordan 1891, Hubba and Miller 1953). Radio-tracking and recapture of tagged razorback suckers demonstrates that some fish

migrate considerable distances to Spawn. Storage and diversion of natural flows have resulted in an 18 percent reduction in mean annual discharge at the Green and Colorado river confluence 26 km (16 mi.) upstream of Lake Powell (U.S. Geological Survey (USGS) flow records, 1906-1982). Storage of high flows during the spring and releases of more water during the remainder of the year have reduced spring runoff by 28 percent in the Green River and 37 percent in the Colorado River during May and June (USGS flow records, 1906-1982). Reduction of these high spring flows has altered the natural flooding cycle and reduced the area of off-stream habitats used by razorback suckers (McAda 1977, Osmundson and Kaedlng tool). Tyus and Karp (1989) believed that flooding of bottomland during spring runoff was important to adults and rearing of young. Onmundson and Kaeding (1991) suggested that flooded bottomlands in the Grand Valley were historically the primary spawning habitats. The lack of recruitment of razorback suckers in the upper basin may be associated with losses of these inundated habitats (Osmundson and Kaeding 1989a and 1090; Tyns and Karp 1989). Dam operations also can cause changes in daily flow regimes. Peaking power operations at Flaming Gorge produced a 400 percent increase in daily flow fluctuations at Jensen. Utah (USGS flow records, 1906—1982J. Tyus and Karp (lg8gJ recommend low, stable flows for razorback suckers during summer, fall, and winter, after finding that such flows are necessary for growth and survival of young native fishes. Stable flows through ice breakup also were important for overwinter survival of young and adult native fishes. Cooler water temperatures, as a result of dam operations, may have excluded the razorback sucker from portions of its original range (Vanicek 1967). Bulkley and Pimentel (19831 showed that adult razorback suckers preferred water temperatures between 22.—25'C (71.8-77'F) and avoided water temperatures below 14.7C (58.5'F) and above 27.4'C (81.3W). Whereas winter temperatures drop well below this reported preference range throughout most of occupied razorback sucker habitat. Razorback suckers have rarely bean captured in these reaches since completion of these dams (Vanicek 1967. Carothers and Minckley 1981). The alteration of temperatures caused by the construction and operation of dams also may affect incubation time and survival of razorback sucker embryos. Incubation time to hatching varies inversely with water temperature, with longer hatching times required at lower temperatures. Gustafson (1975) reported that 55 days were required at 20C (08F1. while Bozek et at. (1984) reported the following incubation periods: 19.4 days at b.C (50'F; 11.1 days at 15C (597J~and 6.8 days at 20C (88W). Marsh (1985) found it required 9 days for larvae to hatch at 15'C (59W) and 3.5 days at 25 C (77F). Most investigators reported poor hatching success at temperatures below I5 degree C (59 degree F) and total mortality of eggs below 1O'C (50'F). However, Bozekci al. (1984) noted only slightly lower survival rates at 10'C (50 degree F) than at 15 and 213'C (59 and 68'F). Alteration of razorback sucker habitat will likely continue because several major reservoirs and water diversionsare in the planning process or are under construction (e.g.. Anirnas-La Plata Project, Muddy Creek Reservoir. Sandstone Reservoir, Central Utah Project). Further loss of flooded bottomland habitat important for spawning is likely to occur as landowners continue dikin~ the Colorado River, particularly in the Grand Valley. Other, less directinfluences such as decreased flow, alteration in stream hydrology, increased dissolved solids, altered temperatures, and other water quality changes may adversely affect therazorback sucker by reducing or degrading its habitat, interrupting spawning, and increasing competition for food and spaceby creating conditions favorable to nonnative fish species. Development activities that most threaten the razorback sucker occur in the upper basin where most of the remaining riverine habitats occur. Since 1980, the Service has conducted consultations , under section 7 of the Act, on over 100 federally funded orregulated projects in the upper basin that involved water depletions. Several transbasin diversions are planned or are under construction. The most prominent is the Central Utah Project which would divert 166,000 sq. ft. of water from the Green

River to the Bonneville Basin.

Stressor: Nonnative species
Exposure: Not assessed
Response: Not assessed
Consequence: Not assessed
Narrative: Several researchers have observed predation of razorback sucker eggs and larvae by carp, channel catfish, smallmouth bass (Micropterus dolomieui), largemouth bass, bluegill, green sunfish, and redear sunfish,(Lepomis microiophus) (Jones and Sumner 1954, Ulmer 1960, Langhorst 1989, Marsh and Laughorat 1988). Other researchers hypothesized that predation is a major cause underlying the Lack of recruitment to the adult razorback sucker population throughout the basin (McAda and Wydoski 1960, Mlnckley 1983, Tyns 1987a). Loudennilk (1985) observed that young razorback sucker larvae inhabited the upper water column for the first few days after swimup and exhibited no defensive behavior from potential predators. Marsh and Langhorst (1988)found larval razorback suckers in Lake Mohave survived longer and grew larger in the absence of predators. Marsh and Brooks 11989) demonstrated that channel catfish and flathead catfish were major prpdators of razorback suckers stocked into the Cila River. They concluded that predation by these fish had potential to result in total loss of thosestocks. Laughorst (b989) reported channel catfish and largemouth bass predation on juvenile razorback suckers averaging 171 mm (6.7 in.) total length stocked in isolated coves along the Colorado River in Califosnia.Two additional predaceous species, the walleye and northern pike have recently become prominent inhabitants of the Green River (Tyusand Beard 1990). The introduction and establishment of nonnative fish species into the Colorado River system is believed by many researchers to have negatively impacted the razorback sucker. Tyus et al. (1982) recorded 42 species that have become established in the upper Colorado River basin, and Minckley (1979) listed 37 nonnative species in the lower basin. Many of these may be innocuous or inhabit areas not occupied by razorback suckers but several are considered serious competitors or predators (Minckley 1983, Loudermilk 1985). In addition to direct predation, competition may result in negative impacts to the razorback sucker, but impacts from competition are more difficult to detect than predation impacts. Although these interactions are not fully understood, normative fish species are hypothesized to impact the razorback sucker due to their considerable numbers, the sharing of common foods, and occupation of the same habitats (Jonez and Sumner 1954). The threat of competition continues as nonnative species continue to be introduced and their ranges continue to expand. The triploid grass carp has been legalized for importation into California and Arizona. In the lower basin, two tilapia species (Tilapia spp.) have become established, and, along with the flathead catfish, have become the dominant fish species in the lower Colorado River (W.L Minckley. Arizona State University. pers. comm. 1989). The rainbow smelt (Osmerus mordax) recently has been proposed for introduction into Lake Powell (Gustaveson et al. 1990). Marsh and Langborst (1988) studied food availability and consumption by larval razorback suckers in Lake Mohave and found that larval razorback suckers consumed a variety of the zooplankters available in the area. Papoulias (1986) found, under experimental conditions, that food items needed to be present at a density of 10 organisms per liter within 10 days of absorption of the yolk sac. Death occurred at about 20—30 days of age if insufficient numbers of zooplankton were present. Intercrossing between razorback suckers and fIannelmouth suckers (Catostorirus latipinnth) was first reported by Hubba and Miller (1953). Vanicek et aL (19;0) and Holden (1973) reported a high incidence of intercrossing between razorback and flannelmouth suckers in the upper basin.

Recovery

Reclassification Criteria:
Downlisting can occur if, over a 5-year period: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and EITHER in the upper Colorado River subbasin or the San Juan River subbasin such that — (a) the trend in adult (age 4+; $400 mm TL) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 (300–399 mm TL) naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults (5,800 is the estimated minimum viable population [MVP] needed to ensure long-term genetic and demographic viability); and (2) a genetic refuge is maintained in Lake Mohave of the lower basin recovery unit; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit (e.g., mainstem and/or tributaries) such that — (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and (4) when certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

New Recovery Priority Number: 7C (USFWS, 2018)

Delisting Criteria:
Delisting can occur if, over a 3-year period beyond downlisting: (1) genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and EITHER in the upper Colorado River subbasin or the San Juan River subbasin such that — (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults; and (2) a genetic refuge is maintained in Lake Mohave; and (3) two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that — (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and (4) when certain sitespecific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Recovery Actions:
- Reestablish populations with hatchery-produced fish.
- Identify and maintain genetic variability of razorback sucker in Lake Mohave.
- Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.
- Provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion.
- Investigate options for providing appropriate water temperatures in the Gunnison River.

- Minimize entrainment of subadults and adults at diversion/out-take structures.
- Ensure adequate protection from overutilization.
- Ensure adequate protection from diseases and parasites.
- Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.
- Control problematic nonnative fishes as needed.
- Minimize the risk of hazardous-materials spills in critical habitat.
- Remediate water-quality problems.
- Minimize the threat of hybridization with white sucker.
- Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).
- RECOMMENDATIONS FOR FUTURE ACTIONS - The UCREFRP, SJRIP and LCR MSCP develop annual work plans through adaptive management (Recovery Implementation Program Recovery Action Plan, Long-Range Plan, and Work Plan and Budget, respectively), to minimize and remove threats to the razorback sucker and promote recovery. We recommend these programs continue to be funded and implemented to further the recovery of razorback sucker. Continued demographic improvements are expected through continued stocking and threat removal performed by these programs. We recommend revising the Service's 2002 Razorback Sucker Recovery Goals to incorporate information gathered since 2002. For example, the recovery goals do not address the threats currently understood from nonnative predators such as smallmouth bass and walleye, nor the importance of floodplain wetland management coupled with spring LTSP dam operations. The population in Lake Powell is not referenced in the recovery goals as the lake was seen as a population sink instead of a potential source habitat. The Service will need to determine how the individuals in Lake Powell contribute to meeting demographic recovery criteria, as appropriate. In addition, the requirement that populations always display positive recruitment (i.e., recruitment that is greater than adult mortality) contradicts the best available information that indicates re-established populations will fluctuate even when recovered. The actions outlined in LCR MSCPs work plan do not include control of nonnative species, restoring natural flow variability below dams, or a future absent of sustained augmentation (with the exception of the Lake Mead population). The Service's definition of recovery will likely need to recognize the concept of conservation reliance and stress the importance of long term commitments to management in various forms (e.g., flow management, floodplain management, nonnative species control, and quite possible some level of augmentation). The Colorado River is one of the most altered ecosystems in the world. The Service should revise recovery goals for this species in these contexts and based on the experiences and information gathered from the four conservation programs (USFWS, 2018).
- Species Needs: We divided the life cycle of razorback sucker into five stages including eggs, larvae, juveniles, adults and spawning adults. During each life stage, razorback sucker require certain resource conditions. This SSA summarizes the following eight resource categories, which are considered the most important: 1. Complex lotic and/or lentic habitat available to razorback sucker (Individual need) 2. Suitable water temperature and quality (Individual need) 3. Variable flow regimes in lotic systems (Individual need) 4. Adequate food supply (Individual need) 5. Range and connectivity (Species need) 6. Population size (Population need - resiliency) 7. Multiple interconnected, naturally recruiting, and resilient populations (Species need - redundancy) 8. Genetic diversity (Species need - representation)

(USFWS, 2018a).

- Risks and Conservation Factors: In addition to species needs, the SSA outlines risks (or stressors) and conservation actions that are currently affecting the species condition and are anticipated to do so in the future. Identified risks include climate change, genetic factors (hybridization, reductions in diversity [e.g. inbreeding]), changes in habitat (flow regime/connectivity, land use, habitat availability, water temperature), and nonnative and invasive species (predation, competition and habitat degradation). Overutilization, parasites, diseases, and pollutants were also considered, and although they were considered risks, were determined to be least impactful. Ongoing and future conservation actions are interrelated and include water management, recovery and conservation program management and funding (including habitat development and management), nonnative species removal, research and monitoring, and hatchery-based augmentation (USFWS, 2018a).
- See Recovery Actions

References

Endangered and Threatened Wildlife and Plants the Razorbasli Suoliss (Xyrauchen toxanus) determined to be an Endangered Species: Final Rule 1991. U.S. Fish and Wildlife Service. 2018. Razorback Sucker (Xyrauchen texanus) 5-Year Review: Summary and Evaluation U.S. Fish and Wildlife Service Region 6 Lakewood, Colorado. 25 pp.

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U.S. Fish and Wildlife Service. 2002. Razorback sucker (Xyrauchen texanus) Recovery Goals: amendment and supplement to the Razorback Sucker Recovery Plan. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

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