APPENDIX H-3

Essential Fish Habitat Summaries for Important LIS Species

Prepared for

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United States
Environmental
Protection Agency

US Army Corps
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LONG ISLAND SOUND
DREDGED MATERIAL DISPOSAL EIS

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LIS-2001-A09-FC2

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1.0 INTRODUCTION

The U.S. Environmental Protection Agency, Regions I and II (EPA), and the U.S. Army Corps of Engineers, New England District (the Corps), are proceeding with the preparation of an Environmental Impact Statement (EIS) in compliance with the National Environmental Policy Act (NEPA). The EIS will consider the potential designation of one or more dredged material disposal sites in the waters of Long Island Sound consistent with the provisions of Section 102 (c) of the Marine Protection, Research, and Sanctuaries Act (MPRSA) and 40 CFR 230.80 of EPA's regulations under Section 404 of the Clean Water Act (CWA).

In 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act, known as the Sustainable Fisheries Act (SFA), emphasized the importance of habitat protection to healthy fisheries and strengthened the ability of the National Marine Fisheries Service and the Mid-Atlantic and New England Fisheries Management Councils to protect and conserve the habitat of marine, estuarine, and anadromous finfish, mollusk and crustaceans. This habitat is termed “essential fish habitat” (EFH) and is broadly defined to include those waters and substrate necessary for fish to spawn, breed, feed, or grow to maturity.

As part of an integrated series of analyses of fish resources, summary statements regarding essential fish habitat were created for 27 species of fish, 1 species of mollusk, and 1 species of crustacean. These summaries provide information on overall distribution, biology, habitat preference and occurrence throughout Long Island Sound. A companion report provides data analysis of Connecticut Department of Environmental Protection (CTDEP) bottom trawl data in Long Island Sound from 1984-2000 (ENSR 2001). A companion database deliverable and GIS utilities provide the EIS technical team with interactive use of all of the CTDEP data for site screening and further analysis of disposal alternatives. A list of important species was developed for trawl data analysis that comprised those species of ecological and commercial importance with sufficient abundance for analysis (ENSR 2001). A companion list of species considered important for ecological and commercial reasons was developed for descriptive purposes (i.e. it was not limited to species with adequate abundance in Long Island Sound to quantitatively analyze). The list below was reviewed by fisheries and marine science staff of CTDEP, NYSDEC, NMFS, FWS, EPA, and the Corps. The final list reflected the collective judgment of all parties; a more extensive list is available for site screening and assessment through the database deliverable. This descriptive list is comprehensive enough to address those species that are most frequently found utilizing Long Island Sound for their life history stages (eggs, larvae, juveniles, adults, and spawning adults).

The species that are included in this report are as follows:

Fish
Alewife
American shad
Atlantic butterfish
Atlantic herring
Atlantic mackerel
Atlantic menhaden
Atlantic salmon
Atlantic sturgeon
Black sea bass
Blueback herring (see Alewife)
Bluefin tuna
Bluefish
Cobia (see King mackerel)
Fourspot flounder
Hogchoker
King mackerel
Pollock
Red hake
Scup
Silver hake
Spanish mackerel (see King mackerel)
Spotted hake
Striped bass
Summer flounder
Tautog
Weakfish
Windowpane flounder
Winter flounder

Invertebrates
American lobster
Long-finned inshore squid

2.0 METHODS

Numerous documents were utilized to provide the information necessary to complete this task. Documents are referenced at the end of each species summary. As an example: Essential Fish Habitat Source Documents, Connecticut Bottom Trawl Survey data report, the New England Fisheries Management Council Northeast Multispecies Guide for Essential Fish Habitat, Status of Fishery Resources off the Northeastern United States, numerous white papers, other technical reports, memorandum, and world wide web sites that include but are not limited to www.fishbase.org, www.larvalbase.org, www.kenshultz.com, www.noaa.gov, and www.nero.nmfs.gov were utilized.

Every effort was made to obtain life history and habitat information regarding eggs, larvae, juveniles, adults, and spawning adults. Obviously, some species have more information about each of these stages than others and this is reflected within the summaries.

3.0 ANALYSIS

Sections 3.1 through 3.25 are descriptions of fish, listed in alphabetical order by common name. Some species are grouped because of similarities. A complete table of individual species, and their groupings, is given in Section 1.0, Introduction. Sections 3.26 and 3.27 are invertebrates.

3.1 ALEWIFE (*ALOSA PSEUDOHARENGUS*) AND BLUEBACK HERRING (*ALOSA AESTIVALIS*)

Designated Lifestages

The coastal areas of Long Island Sound and Block Island Sound are considered part of the essential fish habitat that is designated for only juvenile and adult life stages of alewife and blueback herring. These two species are both anadromous. Eggs and larvae are found upstream in fresh water.

Biology & Distribution

The following summary is based on the information presented in Gottschall *et al.* (2000) and http://www.kenschultz.com.

Alewife are small and silvery gray with a greenish to bluish back tinge. The alewife usually has one small dark shoulder spot and sometimes other small dusky spots. It has large eyes with well-developed adipose eyelids. The alewife can be distinguished from other herring by its lower jaw, which projects noticeably beyond the upper jaw. Blueback herring are distinguished from alewives, as they possess teeth on the roof of the mouth (Mullen *et al.*1986).

Alewives and blueback herring can grow up to a half pound in weight and to 38 cm in length; they usually average 15 to 31 cm in saltwater and 7 to 15 cm in freshwater. Sea-run alewives extend from Newfoundland and the Gulf of St. Lawrence to South Carolina. These species are anadromous, inhabiting coastal waters, estuaries, and some inland waters, although some spend their entire lives in freshwater. The alewife and blueback herring are schooling fish and they can be found in massive concentrations (Mullen *et al.* 1986). Saltwater females deposit 60,000 to 100,000 eggs in freshwater. They deposit the eggs randomly, at night, and both adults leave the eggs unattended. Young alewives and herring hatch in less than a week, and by fall they return to the sea or to deeper waters. Juvenile fish of both species feed on minute free-floating plants and animals, diatoms, copepods, and ostracods; adults feed on plankton, as well as insects, shrimp, small fish, diatoms, copepods, and their own eggs. Adults are planktivores. Juvenile and adult alewife and herring are prey for numerous species of predatory fish and birds.

Habitat Characteristics by Lifestage

In late April through early June, saltwater alewives and blueback herring run up freshwater rivers from the sea to spawn in lakes and sluggish stretches of river (Mullen *et al.* 1986). These species spawn upstream in shallow river pools. Juveniles migrate downstream and adults lead an oceanic life until spawning season when they migrate up their natal rivers and streams.

Distribution & Occurrence in Long Island Sound

Alewives were common in CTDEP trawl catches and became more abundant in recent years, particularly in the spring (ENSR 2001). Gottschall *et al.* (2000) report that 4,419 blueback herring and 5,147 alewife were caught in 2,859 tows between 1984-1994 during the Connecticut trawl surveys. The lower reaches of the Norwalk and Saugatuck Rivers have important anadromous fish runs for sea-run, alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*). Alewives taken in the Survey ranged from 7 to 32cm.

The majority of alewives were juveniles comprising 97-100% of catch in each month. Alewives exhibited a seasonal inshore-offshore pattern. In April, when abundance was highest, alewives in Long Island Sound were distributed primarily in depths greater than 18 m. Abundance was highest over mud bottom, with abundance over transitional and sand bottoms ranking second and third respectively. In May, they were most abundant in depths less than 9 m along the Connecticut shore where many of the largest catches were recorded. During the summer period, alewives were distributed in all depths, particularly south of Guilford, CT on the Mattituck Sill and adjacent portions of the Central Basin. Distribution in fall was similar to spring.

Blueback herring were observed in every month of the survey, ranging from 17.5% occurrence in April to 5.6% occurrence in November. The herring in Long Island Sound ranged in size from 7 to 30 cm. Most observed were juveniles. For most of the year, blueback herring were closely associated with the Connecticut shoreline. During the spring periods, bluebacks were mostly found in depths less than 18 m with the largest concentrations along the Connecticut shore near major rivers. During the summer period bluebacks were more abundant in depths greater than 9 m, with the largest catches occurring in depths greater than 18 m in the Central Basin. By fall, blueback distribution was similar to that of the spring months where they were most abundant along the Connecticut shore in depths less than 9 m. Very few blueback were taken in November in Long Island Sound.

3.2 AMERICAN SHAD (*ALOSA SAPIDISSIMA*)

Designated Lifestages

There is no essential fish habitat designated for American shad, to this date (NOAA, 1998). It is an anadromous species that occurs along the Atlantic coast from southern Labrador to northern Florida. A summary of this species life history traits is taken from http://www.nefsc.nmfs.gov/sos/spsyn/af/shad/.

Biology & Distribution

American shad undergo extensive seasonal migrations, moving into rivers for spawning beginning in January in southern rivers, and continuing until July in the northernmost portion of their range. After spawning, shad migrate north along the coast to Canada where they feed during the summer. A southward migration occurs later along the continental shelf where the fish overwinter prior to spring spawning migrations to their natal rivers (Weiss-Glanz *et al*. 1986).

American shad have a range of life history patterns depending on their river of origin. In southern rivers, shad return to spawn at age 4 and die after spawning. Fecundity ranges from 300,000 to 400,000 eggs. Progressing northward, increasing numbers of spawners survive, the mean age at first spawning increases to 5, and fecundity decreases to 125,000 to 250,000 eggs. The transparent fertilized eggs are carried along by the current. The larvae hatch in 4 to 12 days. Juvenile shad spend their first summer in freshwater. By autumn, the young shad gather in schools and swim to the ocean. They will live in the ocean from three to six years, until sexually mature, then return to freshwater to complete their life cycle (Weiss-Glanz *et al.* 1986).

Excessive fishing has been blamed for historic declines in abundance in the Hudson and Connecticut Rivers, as well as in rivers in Maryland, North Carolina, and Florida. Throughout North America, dam construction along many larger rivers led to an almost complete disappearance of shad in many watersheds and the loss of associated fisheries. Pollution in the lower Delaware has been cited as the primary cause for the past decline of the fishery in that system.

The Atlantic States Marine Fisheries Commission has implemented a coastwide management plan for American shad and river herring to facilitate cooperative management and restoration plans between states. Restoration efforts have involved habitat improvement, fish passage, stocking, and transfer programs. Despite improved returns in some major river systems such as the Susquehanna, Delaware and Connecticut Rivers, the range-wide abundance of American shad is well below historic levels.

The American shad is a plankton feeder. Shad consume copepods, amphipods, small shrimp and fish larvae. Juvenile salmon, sturgeon, sharks, tuna, and other fish and birds are predators of American shad (Weiss-Glanz *et al.* 1986).

Habitat Characteristics by Lifestage

Adult and immature American shad migrate together at sea, generally spending the summer and fall in the Gulf of Maine and the Bay of Fundy. Adults spend the winter in deep waters over the continental shelf along the mid-Atlantic and move toward their natal rivers as spawning season approaches. They spawn in rivers at night in mid-water areas with a wide range of bottom types. The eggs are about 3 mm across and drift along with the current to hatch in 8-12 days, depending on the temperature (Weiss-Glanz *et al.* 1986).

Young shad spend their first summer in the river feeding on insects and crustaceans. They swim near the bottom in water as deep as 3.7-4.9 m but at night they are found near the surface. When they migrate to sea in the fall, they have grown to a size of 7.5-12.5 cm. They migrate to the sea as river temperatures drop. American shad adults stay near the bottom during the day, dispersing at night to all depths. They are not commonly found in the open waters of Long Island Sound but are more abundant along the Connecticut coast.

Distribution & Occurrence in Long Island Sound

American shad had their greatest abundances in the CTDEP trawl catches in the fall season (ENSR 2001). American shad caught in the Connecticut 1984-1994 bottom trawl survey ranged from 8 to 52 cm (Gottschall *et al.* 2000). From April through June 95% ranged from 8 to 28 cm and corresponded to the length at age for ages one and two. Adult shad were most common in June. In August, 97% of the shad taken were age 1+ and ranged from 16-24 cm. The remaining 3% were adult shad that ranged from 40-50 cm. American shad, like alewives, exhibited a seasonal inshore/offshore pattern. During the spring period, shad were most abundant in depths less than 18 m along the Connecticut shore from the Housatonic River to the Hammonasset River, whereas during the summer period shad were more abundant in depths greater than 9 m across the Sound from Connecticut to Long Island in the Central Basin and Mattituck Sill. During the fall period and November, shad distribution was similar to the spring months. Juvenile distribution was similar to that described for the adults.

Almost every major river along the Atlantic seaboard historically supported a spawning population of American shad. They have been exploited for their flesh and roe since prior to Euro-American settlement. Atlantic coast landings exceeded 22,000 million tons (mt) in 1896. In contrast, commercial landings have averaged less than 1,350 mt annually since 1980. Since 1993, annual landings have exceeded 900 mt only once, in 1998. The principal gear used is the gillnet. Recreational angling is popular and catches may be significant, but no comprehensive estimates are available.

The total range of extant American shad populations includes additional populations in small river systems and small populations in larger river systems that are actively being restored. Also, much

historical shad habitat is vacant and may be targeted for restoration in the future. For these stocks, individual states have developed fishing mortality targets to protect small stocks and rebuild others. Assessment studies have not quantitatively addressed these systems because of limited biological data. Like all mixed stock fisheries, small stocks can be at risk under conditions of uncertainty. Overall, this resource is considered to be fully exploited and at low levels of abundance.

3.3 ATLANTIC BUTTERFISH (*PEPRILUS TRIACANTHUS*)

Designated Lifestages

Long Island Sound, Block Island Sound, and the Peconic Estuary are not considered essential fish habitat for any life stage of Atlantic butterfish (NOAA, 1998). However, Cross *et al.* (1999) and Gottschall *et al.* (2000) state that this species may have essential fish habitat in both Long Island Sound and Block Island Sound.

Biology & Distribution

The following summary of Atlantic butterfish biology is adapted from Cross *et al.* (1999) and Gottschall et al (2000).

Butterfish range from Newfoundland and the Gulf of St. Lawrence to the Atlantic and Gulf coasts of Florida but they are most abundant from the Gulf of Maine to Cape Hatteras (Bigelow and Schroeder 1953). Butterfish are fast growing, short-lived, pelagic species that form loose schools (Drey 1988). During the winter, they live near the edge of the continental shelf in the Middle Atlantic Bight and migrate inshore in the spring into southern New England and Gulf of Maine waters. During the summer, butterfish occur over the entire mid-Atlantic shelf from sheltered bays and estuaries out to about 200 m. In late fall, butterfish move southward and offshore. All life stages of this species are entirely oceanic and pelagic.

Butterfish eggs are buoyant, transparent and spherical. The incubation period is about 48 hours at 18°C. At hatching, butterfish are 1.69-1.75 mm.

Butterfish larvae range from 2.6 to 16 mm standard length (SL). By 6 mm they have a thin, deep body that is characteristic of adults. Larvae may undertake diel vertical migrations.

Juvenile butterfish range from 16 mm to 120 mm SL (Martin and Drewry 1978). During their first year, they grow to 76-127 mm, or about half their adult size. Young butterfish often live in the shelter of large jellyfishes during their first summer (Cross 1999).

Adult butterfish range from about 120 mm to 305 mm SL. At 2+ years of age, butterfish are about 17 cm and at 3+ they are about 19 cm (Waring and Murawski 1982).

Butterfish are broadcast spawners and spawn primarily in the evening or at night. Water temperatures appear to regulate butterfish reproduction, as spawning dates are progressively later in the year in the northern part of its range (Murawski et al 1978).

Butterfish feed mainly on planktonic prey including larvaceans, squids, copepods, amphipods, decapods, hydrozoans, polychaetes, small fishes and ctenophores (Cross 1999). Butterfish are preyed on by many species including haddock, silver hake, goosefish, weakfish, bluefish and longfin inshore squid (Cross 1999). Butterfish have a seasonal inshore-offshore north-south migration in response to changing water temperatures north of Cape Hatteras. During the summer, butterfish move north and inshore to feed and reproduce. They remain near the surface at depths of 22-25 m. During the winter, the stock moves south and offshore. Butterfish are found near the bottom over sand, mud and rock bottoms.

Habitat Characteristics by Lifestage

Butterfish eggs and larvae are pelagic and occur from the outer continental shelf to the lower, high salinity parts of estuaries in Middle Atlantic Bight. Larvae may undertake diel vertical migrations. Eggs and larvae are common in the high salinity zones of some estuaries in southern New England and the Middle Atlantic Bight and in the mixing zone in Chesapeake Bay (Cross 1999).

Juvenile and adult butterfish are pelagic fishes that form loose schools, often near the surface. They are frequently found over sand, mud and mixed substrates. In Long Island Sound butterfish were collected less frequently at low dissolved oxygen levels. During the summer, butterfish occur inshore where they remain near the surface. Schools are frequently seen on shallow flats in sheltered bays, estuaries and the surf zone.

Distribution & Occurrence in Long Island Sound

Butterfish were among the most abundant finfish in fall CTDEP trawl catches, particularly in recent years (ENSR 2001). Gottschall (2000) reports that 686,504 fish were taken in 2,859 tows between 1984 and 1994 for the Connecticut Fisheries Division Bottom Trawl Survey. These fish were most abundant in Long Island Sound during the months of Sept-October in habitats bordering Stratford Shoal in the Western and Central Basins and within the CLong Island Sound disposal area. Butterfish eggs have been reported from Narragansett Bay, Block Island Sound, and Long Island Sound. Eggs are most likely to be collected between April through September. Butterfish larvae have been reported from Narragansett Bay, Hudson-Raritan Bay, NJ, Long Island Sound and Block Island Sound. Larvae are most common from May through June. Juvenile butterfish were collected from Narragansett Bay in all seasons but they were rare in winter and spring. They were most abundant in summer when they occurred throughout the bay. In Long Island Sound, butterfish appeared in May, abundance peaked in September-October and declined in November. Adult butterfish have also been reported from southern

New England and the mid-Atlantic. In Narragansett Bay, adult butterfish were collected in all seasons but they were rare in winter and spring.

3.4 ATLANTIC HERRING (*CLUPEA HARENGUS*)

Designated Lifestages

Essential fish habitat has been designated for only juvenile and adult life stages of Atlantic herring along the Connecticut coast in Long Island Sound only.

Biology & Distribution

The following summary of Atlantic herring biology is adapted from Reid *et al.* (1999) and Gottschall *et al.* (2000). The Atlantic herring, *Clupea harengus* is a schooling, coastal pelagic species that inhabits both sides of the North Atlantic Ocean. In the western North Atlantic, they range from Labrador to Cape Hatteras where spring and autumn spawning populations support major commercial fisheries (Messieh 1988). Juveniles and adults undergo complex north-south and inshore-offshore migrations for feeding, spawning and overwintering. Long Island Sound and Block Island Sound are not considered essential fish habitat for herring eggs and larvae.

Larvae metamorphose into juveniles at 40-50 mm total length (TL) in early spring (April-May). Juveniles form large schools in coastal waters throughout the Gulf of Maine and off southern New England, where they have been collected in surveys off Connecticut and southern Massachusetts in May and June. In the summer and fall, juveniles move out of nearshore waters to overwinter in deep bays or near the bottom in offshore areas (Boyar 1968; Kelly and Moring 1986).

Juveniles (and adults) perform vertical migrations that are linked to changing light intensity, most likely in response to movements of their prey (Blaxter 1985).

Both males and females of adult Atlantic herring generally mature between 25-27 cm (Kelly and Moring 1986; O'Brien *et al.*, 1993). Maximum size is about 30 cm TL and maximum age is 15-18 years (Anthony 1972). Adults almost invariably occur in large schools. A reduction in mean weight at age of adults has occurred since 1983.

In general, males and females mature at around 3-4 years old. Three herring spawning stocks have been recognized in the U.S. fishery: southwestern Nova Scotia, coastal Gulf of Maine, and Georges Bank/Nantucket Shoal. Spawning typically takes place between July and November.

Larvae feed opportunistically on whatever zooplankton of appropriate size are abundant (Sherman and Perkins 1971; Kelly and Moring 1986). Their primary prey is copepods. Juveniles feed on up to 15

different groups of zooplankton, the most common are copepods and crustacean larvae. Adults have a diet dominated by euphausiids, chaetognaths, and copepods (Bigelow and Schroeder 1953).

Juvenile and adult herring are preyed on by many marine species including sand lance, cod, pollock, haddock, silver hake, white hake, striped bass, mackerel, billfish, tuna, salmon and winter flounder. Fish predation can be a significant source of mortality, especially at spawning (Kelly and Moring 1986).

Adult herring make extensive feeding, spawning, and overwintering migrations. Schooling behavior begins at metamorphosis (Sindermann 1979; Kelly and Moring 1986). In autumn, this species moves south to waters off Massachusetts and Rhode Island, they return to Maine in the following spring. Juveniles are sometimes abundant in winter and spring in the Hudson-Raritan estuary and in fall in Long Island Sound.

Habitat Characteristics by Lifestage

Herring eggs are usually spawned on horizontal beds at depths of 4-80 m on Georges Bank, 20-50 m in coastal Gulf of Maine, and as shallow as 11-13 m off southwest Nova Scotia. Eggs are laid on gravel, sand, rocks, shell fragments and other aquatic structures such as lobster pots (Kelly and Moring 1986).

Larvae occur at temperatures of 9-16°C in the Gulf of Maine. Survival and growth in winter may be enhanced in offshore waters, which are up to 5°C warmer than inshore waters.

In Narragansett Bay, relative abundance of juveniles was high at bottom depths of 30 m in all seasons and at 9-27 m in Spring. In the Hudson-Raritan Estuary, herring were found at 2-6°C and 12-22°C but were most abundant at 4-6°C and at 15-18°C. There were few differences in abundance over the range of depths and salinities sampled.

Distribution & Occurrence in Long Island Sound

Since eggs and larvae are not found in Block Island Sound or Long Island Sound, they are not treated in this summary.

Atlantic herring were among the most abundant finfish species in spring CTDEP trawls (ENSR 2001). Atlantic herring adults had their greatest abundance in CTDEP trawls from April through June, very few Atlantic herring adults are found in Long Island Sound during the months from June through October. The seasonal distribution pattern and abundance of juvenile and adult herring were similar. In spring, juveniles and adults were most abundant shelf-wide from Long Island Sound to the waters around Cape Cod, and in Massachusetts Bay. In winter, herring were caught throughout the Middle Atlantic Bight and on southern Georges Bank. Catches of juveniles were patchy in Narragansett Bay. Catches were highest in summer when the largest mean catch (254 fish/tow) occurred at a station farthest offshore.

Abundance was lower during the remaining seasons. Adults were scarce in winter when the highest mean catch was 12 per tow. In spring, herring were abundant in shallow habitats in central and western Long Island Sound (ENSR 2001). Juveniles were not separated from adults, but most fish were 26-30 cm long. Catches were much smaller in autumn and occurred mostly along the west-central coast (Gottschall *et al.* 2000).

Catches of all sizes of herring were distributed evenly throughout the Hudson-Raritan estuary. Juveniles were most abundant in winter and spring throughout the lower estuary. Adults were most common in winter, which is consistent with the fact that adults from the Gulf of Maine overwinter south of Cape Cod (Sindermann 1979).

3.5 ATLANTIC MACKEREL (*SCOMBER SCOMBRUS*)

Designated Lifestages

Essential fish habitat is designated for juvenile and adult life stages of Atlantic mackerel throughout Long Island Sound and Block Island Sound. Eggs and larvae of this species are not as widely distributed throughout these Sounds as the juveniles and adults. Eggs and larvae are typically found close to the shoreline of Connecticut and Rhode Island.

Biology & Distribution

The following summary of Atlantic mackerel biology is adapted from Studholme *et al.* (1999).

Atlantic mackerel, *Scomber scombrus* is a fast swimming, pelagic schooling species distributed in the northwest Atlantic from the Gulf of St. Lawrence to Cape Lookout, North Carolina (Sette 1943). Since 1975, all Atlantic mackerel in this area have been assessed and are considered as one stock species, despite regional anatomical differences, for management purposes (Anderson 1982).

The eggs of Atlantic mackerel are pelagic and spherical and range in size from 1.01-1.28 mm. Long Island Sound and Block Island Sound are not considered essential fish habitat for Atlantic mackerel eggs.

Larvae average about 3.1-3.3 mm standard length (SL) at hatching. Larvae undergo major changes in body form and Sette (1943) describes a transition stage between the larval and post-larval stages where fins are in various stages of development.

Post-larvae transform from planktonic to swimming and schooling behavior at about 30-50 mm (Sette 1943). Fish reach a length of about 50 mm in approximately 2 months.

By the end of the second year, Atlantic mackerel attain a size of about 26 cm and after five years about 33 cm (Anderson, 1973). The adults are highly mobile and school. They are obligate swimmers due to

the absence of a swimbladder and the necessity for ram gill ventilation to meet oxygen demands (Roberts 1975). Fish continue to school both day and night although they exhibit slower swimming during the night and faster swimming during the day (Olla et al 1975).

Atlantic mackerel are opportunistic feeders that can ingest prey either by individual selection of organisms or by passive filter feeding (Pepin 1988). Larvae feed primarily on zooplankton. Juveniles eat mostly small crustaceans such as copepods, amphipods and mysid shrimp. They also feed on small pelagic mollusks. Adults feed on the same food as juveniles but diets also include a wider assortment of organisms and larger prey items.

Atlantic mackerel serve as prey for a wide variety of predators including other mackerel, dogfish, tunas, bonito and striped bass. Small mackerel are prey for Atlantic cod and squid. Pilot whales, common dolphins, silver hake, red hake, bluefish, Pollock, white hake and weakfish, along with numerous other fish species all prey on Atlantic mackerel.

Atlantic mackerel apparently over-winter in the deep water of the continental shelf from Sable Island Bank, off Nova Scotia, southward to the Chesapeake Bay region. In spring, this species moves inshore and northeast (Sette 1950, Leim and Scott 1966). In April and early May, Atlantic mackerel living in warmer southern waters spawn in April and early May. This includes individuals found off New Jersey and New York. After spawning, some individuals of this southern contingent can migrate and be found off New England where they mix, temporarily, with the northern contingent individuals. The northern contingent Atlantic mackerel, by late spring, move inshore off southern New England and then migrate eastward along the coast of Nova Scotia and moving into the Gulf of St. Lawrence where they spawn in June and July.

Habitat Characteristics by Lifestage

Eggs are pelagic in water over 34 ppt (Fritzsche 1978) floating in surface waters in the upper 10 – 15 cm. In May, the majority of larvae can be found at 8-10°C; in June at 8-11°C and at slightly warmer temperatures as summer progresses. Ware and Lambert (1985) found that mortality rates were positively correlated with temperature increases.

Juveniles in the fall were caught at temperatures ranging from 4-22°C with the majority occurring at 10°C. In the winter 90% were collected from the NEFSC bottom trawl survey at 5-6°C. In the fall, the majority of juveniles were at depths of 20-40 m.

Adults are found at temperatures ranging from 4-16°C. Winter distribution is similar to that of juveniles with adults found in water temperatures around 5°C. In the spring and summer, adults are more evenly

distributed throughout the water column and at a variety of water temperatures. Atlantic mackerel are intolerant to water temperatures < 5-6°C and > 15-16°C.

Distribution & Occurrence in Long Island Sound

Atlantic mackerel are not abundant in Long Island Sound. Only a single adult of Atlantic mackerel was caught in winter at a depth of 30.5 m and a bottom temperature of 5°C. A total of 92 Atlantic mackerel were caught during the Rhode Island Narragansett Bay bottom trawl surveys. They were captured in low numbers at nearly all stations. Juveniles were present in summer and autumn and a single adult was caught in winter. Survey data from the Connecticut bottom trawl surveys in Long Island Sound indicated that although few Atlantic mackerel were collected, analysis of length-frequency data indicated that both juveniles and adults were present at different times and distributed differently (Gottschall et al 2000). Gottschall et al (2000) reports that only 635 adult Atlantic mackerel were taken in 2,859 tows across Long Island Sound. The greatest abundance of these fish was found in Long Island Sound during the months of April and June.

3.6 ATLANTIC MENHADEN (*BREVOORTIA TYRANNUS*)

Designated Lifestages

Neither Block Island Sound, Long Island Sound nor the Peconic Estuary system have essential fish habitat listed for any life stage. However, Atlantic menhaden are found in these estuaries but not in great numbers (Gottschall 2000). Life stages found in Block Island Sound, Long Island Sound, or the Peconic estuary are juvenile and adult only.

Biology & Distribution

The following summary is based on the information presented in Gottschall *et al.* (2000) and http://www.kenschultz.com/.

A member of the herring family, the Atlantic menhaden is a hugely important fish meal commercial species; greater numbers of this fish are taken each year by commercial fishermen than of any other fish in the United States. Excessive fishing of this species has caused population declines.

The Atlantic menhaden has a deep and compressed body, a big bony head, and a large mouth with a lower jaw that fits into a notch in the upper jaw. It has a dark blue back, silvery sides with an occasional reddish or brassy tint, pale-yellow fins edged in black, a dark patch on the shoulder, and two or three scattered rows of smaller spots. The Atlantic menhaden can reach a length of 46 cm. This species occurs in the western Atlantic Ocean from Nova Scotia to the Indian River in southern Florida (Rogers and Van Den Avyle 1983). Atlantic menhaden inhabit inland tidal areas of brackish water and coastal

saltwater. They migrate in and out of bays and inlets, and are found inshore in summer. Some populations move into deeper water in winter. This species moves upstream, into the higher part of the estuary, to spawn. They are often seen near the surface of the water in large schools of thousands of fish. Menhaden feed chiefly on phytoplankton and small crustaceans sifted from the water with their highly specialized comb-like gill rakers (Rogers and Van Den Avyle 1983). The species spawns at sea from June through August in the northern part of its range and late autumn through winter in the southern part. A single female can lay over 140,000 eggs, which are buoyant and develop rapidly, usually hatching within 48 hours. *Brevoortia tyrannus* is an important food species for other fish. This species has little commercial value as a human food source but is industrially important for conversion to fishmeal; the U.S. harvests over 500 million kg. per year. Atlantic menhaden are an important forage fish for whales, porpoises, sharks, swordfish, tuna, striped bass, and seabirds (Rogers and Van Den Avyle 1983).

Habitat Characteristics by Lifestage

Sexual maturity is reached at 2-3 years of age. Spawning occurs within inshore waters mostly during the fall and winter in the ocean from the Carolinas to New Jersey, over the continental shelf. Currents, along with swimming, move the larvae to the less saline waters of tidal creeks with sandy bottoms and into estuarine nursery areas where they transform into juveniles and remain until the fall, when they migrate to the ocean. Most juveniles and adults throughout the Atlantic coast gather in large schools off North Carolina during November-January before dispersing for the rest of the winter. During April and May, menhaden migrate northward along the coast, with the larger, older fish going farthest north, and younger, smaller fish staying in southern areas for the summer.

Distribution & Occurrence in Long Island Sound

Atlantic menhaden were not highly abundant in Long Island Sound. Gottschall *et al.* (2000) reports on the presence of 5,291 Atlantic menhaden taken from 2,859 tows from 1984-1994 as part of the Connecticut bottom trawl survey. Menhaden first appeared in survey catches in April and increased in abundance through fall. From April through August, catches of menhaden were highest near New Haven Harbor, CT in depths less than 28 m. In September and October, catches were highest along the CT shore from New Haven Harbor to Norwalk. By November, they were concentrated farther east along the shore from Milford to Guilford, and from Guilford across the Sound toward Mattituck. The New Haven Harbor area had consistently high catches during all seasons.

Although menhaden length data were not available, weights taken in the spring and fall periods from 1992 to 1994, in addition to observations recorded on field sheets, provided information about size composition. From April to June the average size of the menhaden was 28 cm (Wilk *et al.*, 1978), indicating many of these menhaden were adults. From September through October, the mean size was 17 cm indicating most were juveniles.

3.7 ATLANTIC SALMON (*SALMO SALAR*)

Designated Lifestages

Long Island Sound is considered essential fish habitat for juvenile and adult Atlantic salmon (NOAA 1998). Eggs, spawning adults and larvae are restricted to freshwater rivers as this is an anadromous species. There are only three rivers in Maine documented as having spawning native Atlantic salmon present. Spawning Atlantic salmon, from the native population, are not found in any Connecticut river (NOAA 1988). There was a brief period in the late 19th Century when limited runs were reestablished in the Merrimack and Connecticut Rivers by artificial propagation, but these runs were extirpated by the end of the century (USFWS, 1994). Salmon runs in the large rivers south of the Kennebec River, Maine, disappeared during this same period (Kendall 1939). By the end of the 19th Century, three of the five largest salmon populations in New England (in the Connecticut, Pawcatuck, Merrimack, and Androscoggin Rivers) had been eliminated, shifting the southern extent of the wild species' distribution approximately 2^{o} north in latitude and 4^{o} east in longitude. There is a large effort, currently, to farm salmon in pens along the coast of northeast Canada and Maine. These individuals are genetically different from the native Atlantic Salmon population. Escaped farmed-raised salmon have the potential to spawn with native salmon and thereby decrease chances of maintaining wild Atlantic salmon populations even further.

Biology & Distribution

The following summary of Atlantic salmon biology is adapted from NOAA (1998) and Oanie *et al.* (1984). Gottschall *et al.* (2000) did not include Atlantic salmon data in the summary of the results from the Connecticut Long Island Sound bottom trawl survey conducted from 1984-1994 because they are rarely found in Long Island Sound. It was not mentioned in the text of Gottschall *et al.* (2000) if any incidental Atlantic salmon individuals were found during the period of the CTDEP trawl survey. Eggs are spawned in rivers with the water temperature below 10°C, where the waters are clean and well-oxygenated. Salmon eggs are most frequently observed between October and April.

The essential fish habitat designation for Atlantic salmon eggs and larvae represent all rivers where Atlantic salmon are currently present (26 rivers). The Connecticut River that empties into Long Island Sound and the Pawcatuck River that enters into Block Island Sound are considered essential fish habitat for Atlantic salmon.

Larvae hatch in April or May of the following spawning year. Clean, well-oxygenated freshwater, water temperatures below 25°C, depths between 10-61 cm, and water velocities between 30 and 92 cm per second are necessary for survival of juvenile Atlantic salmon. As the juveniles transform into smolts the salmon require access to downstream to make their way to the ocean. Upon entering the sea, “post-

smolts" become pelagic and range from Long Island Sound north to the Labrador Sea (Oanie *et al.* 1984).

Adult Atlantic salmon start their migratory return in May and require access to their natal streams and access to the spawning grounds. Water temperature must be below 22.8°C and dissolved oxygen above 5ppm. Oceanic adult Atlantic salmon are primarily pelagic and range from the waters of the continental shelf off southern New England north throughout the Gulf of Maine.

Atlantic salmon are preyed upon by seals, Atlantic cod, hagfish, shoreline mammals, yellowfin tuna and birds such as great egrets and eagles. Adult salmon prey upon alewife, smelts, herring, yellow perch, insects and crustaceans. Larvae and juveniles will feed on insects in streams (Oanie *et al.* 1984).

Construction of dams, overfishing and pollution are assumed to be the three major reasons why the Atlantic salmon population is declining (NOAA 1988).

Habitat Characteristics by Lifestage

Eggs of Atlantic salmon locate in bottom habitats with gravel or cobble riffle above or below a pool of rivers. Larvae locate in bottom habitats with gravel or cobble riffle similar to that of the eggs. Juveniles prefer bottom habitats of shallow gravel/cobble riffles interspersed with deeper riffles and pools in rivers and estuaries (Oanie *et al.* 1984). Adult Atlantic salmon return to spawn, from the ocean, to habitats with resting and holding pools in rivers and estuaries.

Distribution & Occurrence in Long Island Sound

Little information is available on the distribution and occurrence of juvenile or adult Atlantic salmon in Long Island Sound. This species was once commonly found in Long Island Sound and in the rivers that feed into the Sound, however this is no longer true. Efforts are being made in Connecticut to restore habitat, remove dams, and to stock streams to help the Atlantic salmon regain its abundance in this area.

3.8 ATLANTIC STURGEON (*ACIPENSER OXYRINCHUS*)

Designated Lifestages

The entire of Long Island Sound is designated as essential fish habitat for juvenile and adult life stages of Atlantic sturgeon only. Block Island Sound and the Peconic Estuary are not considered essential fish habitat for the Atlantic sturgeon. Eggs and larvae of this species are not found in Long Island Sound. This species is anadromous and its eggs and larvae are found in the Connecticut and Hudson Rivers.

Biology & Distribution

The following summary is based on the information presented in Gottschall *et al.* (2000) and http://www.kenschultz.com/template2.asp?fishname=Sturgeon,%20Atlantic and Van Den Avyle (1984).

The Atlantic sturgeon is dark brown or olive green with a white belly. The head is protractile and has a long flat snout with four barbels on the underside. Five rows of scutes (bony scalelike plates) extend along the length of the body; one is along the back, and two each are along the sides and belly. The centers of the scutes along the back and sides are light, making them stand out in contrast to the darker surrounding color. These scutes are set extremely close together, and the bases of most overlap (Gilbert 1989).

Atlantic sturgeon may live as long as 60 years. They can attain a size of 5 m and weigh more than 800 pounds. Fish exceeding 200 pounds, however, are rare today. The habitat of Atlantic sturgeon is primarily the estuaries and bays of large rivers, and deep pools of rivers when inland; in the ocean it inhabits shallow waters of the continental shelf (Gilbert 1989). Spawning migrations to freshwater last from late winter through early summer, occurring later in the year at higher latitudes. Although this species matures late in life, the Atlantic sturgeon is highly fecund, with total egg production proportional to its body size (a 2.7 m, 245-pound female, about 30 years old, produced 61 pounds of roe). Nevertheless, it has a low reproduction rate, as females spawn only once every 3 to 5 years, and juvenile mortality is high. Furthermore, females do not mature until ages 7 to 10 in the southern part of their range, and ages 22 to 28 in the most northern part of their range; these late maturations complicate management efforts, especially because the fish are at sea for long periods, until they return to natal waters to spawn.

Juveniles and adults are bottom-feeding and prey upon a variety of crustaceans, bivalves, and worms, as well as small fish. Sturgeon are opportunistic feeders and will likely consume whatever types of bottom-dwelling organisms are present. In the sea, large sturgeon feed on mollusks and other bottom organisms. They have been reported to eat polychaete worms, gastropods, shrimps, isopods, amphipods, and small bottom-dwelling fishes. Adults apparently do not eat while migrating upstream to spawn (Van Den Avyle, 1984; Gilbert 1989).

There is virtually no sport fishery for Atlantic sturgeon, due to their low numbers and to harvest restrictions. Most fisheries are now closed in compliance with the Atlantic sturgeon management plan of the Atlantic States Marine Fisheries Commission, but the outlook is still poor, and much needs to be done to bring about even a modest growth in populations. Minimum size limits, harvest restrictions, and closed seasons exist in some states.

Habitat Characteristics by Lifestage

Juvenile Atlantic sturgeon prefer mesohaline and deeper portions of their river habitat. Atlantic sturgeon spawn in running, brackish, or fresh water as deep as 3 m over small rubble or gravel. The nursery areas are broad reaches of the rivers in downstream, tidally influenced transition zones having hard sand or shale substrates (Van Den Avyle, 1984). Most Atlantic sturgeon are caught in coastal areas, but some are taken from shelf waters and offshore fishing grounds at depths down to 50 m (Van Den Avyle, 1984).

Juvenile sturgeon remain in freshwater for their first summer of life and then migrate to deeper more brackish water in winter. The juveniles migrate to and from freshwater for a number of years before joining the adult migration pattern. Tagging studies have demonstrated that Atlantic sturgeon migrate extensively both north and south of their natal river systems (Gilbert 1989).

Distribution & Occurrence in Long Island Sound

Gottschall *et al.* (2000) reports on the distribution and occurrence of 208 Atlantic sturgeon fish taken in 2,589 tows between 1984-1994. These fish had their greatest abundance in Long Island Sound during the months of September through October. Atlantic sturgeon individuals taken in the CTDEP survey ranged from 72 to 141 cm and were probably juveniles. Although Atlantic sturgeon was not often observed they were taken in all months from May through November, in Long Island Sound. Most Atlantic sturgeon were found in the eastern half of the Sound, especially from the mouth of the Connecticut River on sand bottom in depths less than 9 m to deeper sand and transitional areas in the Eastern Basin and Mattituck Sill, and further south into a 27+ m mud area in the Central Basin. The largest sturgeon concentrations were observed in September in two areas: south of Guilford, CT on transitional bottom in depths greater than 27 m, and in the 27+ m mud area in the Central Basin. Overall, the greatest numbers of sturgeon were taken on transitional bottom in depths greater than 27 m.

3.9 BLACK SEA BASS (*CENTROPRISTIS STRIATA*)

Designated Lifestages

Essential fish habitat is designated for juvenile life stages of black sea bass in Long Island Sound, Block Island Sound, and the Peconic Estuary. Very few adults are found in these areas. Eggs and larvae are rarely found in Long Island Sound, Block Island Sound or the Peconic Estuary.

Biology & Distribution

The following summary of black sea bass biology is adapted from Steimle *et al.* (1999a) and Gottschall *et al.* (2000). Black sea bass are a warm temperature species that is usually associated with structured habitats, such as reefs and shipwrecks, on the continental shelf. It occurs from southern Nova Scotia and

the Bay of Fundy to southern Florida (Bowen and Avise 1990, Scott and Scott 1998) and into the Gulf of Mexico. It is uncommon or occurs irregularly in the cool waters north of Cape Cod (Short 1992). This species exists as three populations: northern, southern, and Gulf of Mexico. The northern stock that occurs north of Cape Hatteras is the stock discussed below.

As coastal waters cool below 14°C in the fall, the Middle Atlantic Bight population begins to migrate south and offshore to wintering areas in deeper waters between central New Jersey and North Carolina. As bottom waters warm above 7°C in the spring, the population migrates inshore into coastal areas and bays in southern New England and the Middle Atlantic Bight.

Black sea bass usually mature as a female and with increasing size change sex to male. In the Middle Atlantic Bight, they grow to over 60 cm TL and live up to 20 years. The largest and oldest fish are usually males (Bigelow and Schroeder 1953).

The northern population of black sea bass spawns buoyant, pelagic eggs on the continental shelf from spring through fall (Able and Fahay, 1998). Spawning begins in the spring in the southern part of its range and progresses north into southern New England waters from summer through fall. In the Middle Atlantic Bight, the incubation period is five days at 15°C.

Larvae are 1.5-2.1 mm standard length (SL) at hatching (Fahay 1983). The duration of the pelagic larval stage is unknown. Most juvenile settlement does not occur in estuaries, but in coastal areas. Young-of-the-year black sea bass enter the Middle Atlantic Bight estuaries from July to September (Able *et al.* 1995a). Juvenile black sea bass grow relatively fast in estuaries during the summer.

Growth is sexually dimorphic in mature black sea bass. Females grow faster but reach a lower maximum size (Lavenda 1949). Males grew faster than females off New York based on otolith annuli analyses of year 1 and older fish (Alexander 1981). Fish from the Middle Atlantic Bight were larger and grew faster than fish from South Atlantic Bight (Mercer 1978). Growth is linear to about age 6, then slows.

The diet of larval black sea bass probably consists of zooplankton. Juvenile black sea bass are diurnal, visual predators and often prey on small benthic crustaceans and other epibenthic estuarine and coastal organisms. During the summer, adult black sea bass feed on a variety of infaunal and epibenthic invertebrates, small fish, and pelagic squid and baitfish (Steimle *et al.* 1999). The diets and feeding of the offshore wintering population are poorly known.

There are many potential predators on larval black sea bass. Jellyfish, of a variety of species, can feed on black sea bass. Summer flounder, smooth dogfish, and oyster toadfish are potential predators. Bluefish, striped bass and weakfish can also feed on juveniles in the water column. Adults can be preyed

upon by spiny dogfish, Atlantic angel shark, clearnose skate, spotted hake, summer and windowpane flounder (Steimle *et al.* 1999).

Black sea bass belong to a group of warm temperate migrating species that do not tolerate cold, inshore winter conditions, similar to scup, summer flounder, northern sea robin, spotted hake, butterfish and smooth dogfish (Musick and Mercer 1977). The summer coastal population migrates in scattered aggregates in the fall by generally unknown routes from inshore areas across the continental shelf to outer shelf wintering areas south of New Jersey. Offshore migrations are stimulated in the fall as coastal bottom water temperatures approach 7°C and the return inshore migration begins in the spring as inshore bottom water temperature rise above this temperature (Nesbit and Nevill 1935).

Habitat Characteristics by Lifestage

Buoyant eggs were collected in waters <50 m in May and October. However, some eggs were collected in waters >240 m. The spawning period, for this species, is quite long, begins in the spring, and extends into the fall.

Larvae were collected at an average water column temperature of 11-26°C. Larvae were generally collected at depths of <100 m but several collections occurred over water deeper than 200 m.

Juveniles were collected from about 20-240 m at bottom water temperatures >5°C in the winter and spring. The estuarine nursery habitat of black sea bass is shallow, hard bottom with structure. Able et al (1995b) reported little use of eelgrass beds. Juveniles were not common on open, unvegetated sandy intertidal flats of beaches or deeper muddy bottoms (Steimle *et al.* 1999).

Adult black sea bass orient to structures, especially during their summer residency in coastal waters. Adults tend to enter only larger estuaries and are most abundant along the coast. Larger fish are found in deeper water and occur on shipwrecks, rocky and artificial reefs, mussel beds and other bottom objects. In the Middle Atlantic Bight, black sea bass adults spend the winter on the middle to outer continental shelf between 30-240 m. The offshore habits occupied by adult black sea bass during the winter are poorly known (Steimle *et al.* 1999)

Distribution & Occurrence in Long Island Sound

The geographic distribution of the northern population of adult black sea bass is similar to the distribution of juveniles, although adults tend to prefer deeper bays and coastal waters rather than estuaries. Black sea bass is normally considered a reef fish. In warmer months, they are usually closely associated with sheltering habitat in estuarine and coast waters generally at depths <40 m. In Narragansett Bay adults were rare but they were collected from a wide range of sites from spring to fall. In Long Island Sound,

adults were most common in the spring survey in the central sound. Adult black sea bass were never common in the Hudson-Raritan estuary (Steimle *et al.* 1999).

Black sea bass were relatively rare in CTDEP trawls (ENSR 2001). The greatest abundance of this species occurred from April-June (Gottschall *et al.* 2000). Black sea bass were caught in shallow nearshore habitats and in the central part of Long Island Sound but catches never exceeded 1.2 fish per tow (ENSR 2001).

3.10 BLUEFIN TUNA (*THUNNUS THYNNUS*)

Designated Lifestages

Long Island Sound is not formally designated as essential fish habitat for bluefin tuna. However, there are two areas just around the North Fork of Long Island that are designated as essential fish habitat for bluefin tuna along with the waters associated with Block Island Sound. The Peconic Estuary is not essential fish habitat for this species. This species has extensive migration and tends to be found offshore. These areas have essential fish habitat for bluefin tuna juveniles and adults only (NOAA 1998).

Biology & Distribution

The following summary is based on the information presented in the Fisheries Management Plan for Highly Migratory Species including Atlantic Tunas, Swordfish and Sharks. (NOAA 1999a). Information was also taken from http://www.kenschultz.com.

In the western north Atlantic, bluefin tuna range from 45° N to 0° (Collette and Nauen, 1983). However, they have recently been found up to 55° N in the west Atlantic (Vinnichenko, 1996). Bluefin tuna move seasonally from spring (May and June) spawning grounds in the Gulf of Mexico through the Straits of Florida to feeding grounds off the northeast U.S. coast (Mather *et al.*, 1995). It is believed that there is a single stock that ranges from Labrador and Newfoundland south into the Gulf of Mexico and the Caribbean, and also off Venezuela and Brazil. From November to January bluefin tuna are concentrated into two separate groups, one in the northwest and the other in the north central Atlantic. In February the central Atlantic aggregation breaks up, with some fish moving southeast to the Azores and some moving southwest (Suda, 1994). Southerly movements from the feeding grounds off the northern United States and wintering areas are not well understood. A three-way movement among spawning, feeding and wintering areas is assumed for mature fish, and a shorter, two-way feeding-to-wintering movement for juveniles (Mather *et al.*, 1995).

Bluefin tuna distributions are probably constrained by the 12°C isotherm, although individuals can dive to 6° to 8°C waters to feed (Tiews, 1963). Year-to-year variations in movements have been noted (Mather *et al.*, 1995). While bluefin tuna are epipelagic and usually oceanic, they do come close to shore

seasonally (Collette and Nauen, 1983). They often occur over the continental shelf and in embayments, especially during the summer months when they feed actively on herring, mackerel and squids in the north Atlantic. Larger individuals move into higher latitudes than do smaller fish. Bluefin tuna are often found in mixed schools with skipjack tuna, these schools consisting of similarly sized individuals (Tiews, 1963).

Bluefin tuna larvae initially feed on zooplankton but switch to a piscivorous diet at a relatively small size. Small bluefin tuna larvae prey on other larval fishes, and are subject to the same predators as these larvae, primarily larger fishes and gelatinous zooplankton (McGowan and Richards, 1989). Adults consume squids, pelagic crustaceans, and schooling fishes such as anchovies, sauries and hakes, depending on seasonal prey availability. Predators of adult bluefin tuna include toothed whales, swordfish, sharks and other tuna (especially of smaller individuals).

The habitat requirements for larval success are not known, but larvae are collected within narrow ranges of temperature and salinity - approximately 26°C and 36 ppt - along the coast of the southeastern United States where onshore meanders of the Gulf Stream can produce upwelling of nutrient rich water along the shelf edge. In addition, compression of the isotherms on the edge of the Gulf Stream can form a stable region which, together with the upwelled nutrients, provides an area favorable to maximum growth and retention of food for the larvae (McGowan and Richards, 1989).

Bluefin tuna are warm blooded and able to maintain their body temperatures up to 18°F above the surrounding water, which makes them superbly adapted to temperate and cold waters. They retain 98% of muscular heat, may have the highest metabolism of any known fish, and are among the fastest and most wide-ranging animals on earth. When hunted or hunting, they can accelerate to 35 miles per hour.

Bluefins are schooling fish and do congregate by size, although the largest schools are formed by the smallest individuals, and the smallest schools are composed of the largest fish. They swim in a single file, side by side (soldier formation), or in an arc (hunter formation). Sometimes bluefins swim below a school of yellowfin tuna, relying on the skittish yellowfin to alert them of predators.

Habitat Characteristics by Lifestage

The general habitat requirements for larval success are not known, but it is known that larvae are collected within narrow ranges of temperature and salinity - approximately 26°C and 36 ppt - along the coast of the southeastern United States, where onshore meanders of the Gulf Stream can produce upwelling of nutrient rich water along the shelf edge. In addition, compression of the isotherms on the edge of the Gulf Stream can form a stable region which, together with the upwelled nutrients, provides an area favorable to maximum growth and retention of food for the larvae (McGowan and Richards, 1989).

Extensive migrations appear to be tied to water temperature, spawning habits, and the seasonal movements of forage species. Specimens tagged in the Bahamas have been recaptured as far north as Newfoundland and Norway and as far south as Uruguay. In some cases, the recaptured fish had traveled 5,000 miles in 50 days.

During spawning, a giant female may shed 25 million or more pelagic eggs. Pelagic larvae have one chance in 40 million of reaching adulthood eight years later, but the survivors grow rapidly and may be 0.5 m long and weigh 9 pounds by the end of their first year. By age 14 they may be more than 3.5 m long and weigh 700 pounds.

Distribution & Occurrence in Long Island Sound

Neither Gottschall *et al.* (2000) nor Clark (1998) report on the presence of bluefin tuna in Long Island Sound, however, NOAA (1998) states that Block Island Sound and the mouth of Long Island Sound, near the North Fork, are essential fish habitat for juveniles and adults of this species. Bluefin tuna are most likely to be found nearshore from July through November.

3.11 BLUEFISH (*POMATOMUS SALTATRIX*)

Designated Lifestages

Essential fish habitat is designated for juveniles and adults of bluefish across all of Long Island Sound, throughout Block Island Sound, and the Peconic Estuary (NOAA 1998).

Biology & Distribution

The following summary of bluefish biology is adapted from Fahay *et al.* (1999) and Gottschall *et al.* (2000). Bluefish travel in schools of like sized individuals and undertake seasonal migrations, moving into the Middle Atlantic Bight during spring and south or farther offshore during fall. Within the Middle Atlantic Bight, they occur in large bays and estuaries as well as across the entire continental shelf. Eggs and larvae occur in oceanic waters (Able and Fahay 1998).

Eggs are pelagic and spherical with a diameter of 0.95-1.00 mm. Incubation times depend on temperature. At 18.0-22.2°C hatching occurs after 46-48 hours (Deuel *et al.* 1966; Oliver *et al*. 1989).

Larvae are 2.0-2.4 mm long when they hatch. Teeth are well developed at 4.3 mm and fin rays are complete at a size of about 13-14 mm (Fahay 1983; Oliver *et al.* 1989). The bluefish transforms from a larva to a “pelagic-juvenile” stage that is specially adapted for an oceanic, near-surface existence after completion of fin ray development. Juveniles have a usual fish shape without unusual features. The mouth is large and two distinct dorsal fins touch at their bases. The spring-spawned cohort has a mean

size of 60 mm when they recruit to estuarine habitats in the Middle Atlantic Bight in late May to mid-June (McBride and Conover 1991). The summer-spawned cohort either remains in coastal nursery areas or enters estuarine nurseries in mid- to late August when they are a mean length of 46 mm (McBride and Conover 1991). Juveniles of both cohorts depart Middle Atlantic Bight estuaries and coastal areas in October and migrate to waters south of Cape Hatteras, North Carolina.

Adult bluefish are blue-green above, silvery below and armed with stout teeth along both jaws. The maximum length is about 115 cm and maximum weights are 4.5-6.8 kg. The maximum age is 12 years. Recent studies have re-examined spawning times from Atlantic bluefish and have suggested that a single, migratory spawning occurs (Hare and Cowen 1993). In the New York Bight, studies indicated that both sexes reach maturity between June and September with a strong peak in July (Chiarella and Conover 1990). Most bluefish mature by age 2.

During their oceanic larval stage, bluefish primarily consume copepods. The results of several studies suggest that bluefish juveniles and adults eat whatever taxa are locally abundant. This includes fish, crustaceans, and polychaetes. Sharks, tunas, and billfishes are the only predators large and fast enough to prey on adult bluefish. Young-of-the-year are preyed upon by four oceanic bird species, the Atlantic puffin, Arctic tern, common tern and roseate tern (Creaser and Perkins 1994). Cannibalism is rarely reported, bluefish compose a minor component of the diet of larger bluefish collected during the Northeast Fisheries Science Center (NEFSC) bottom trawl surveys on the continental shelf.

Bluefish are warm water migrants and do not occur in Middle Atlantic Bight waters at temperatures <14-16°C (Bigelow and Schroeder 1953). They generally move north in spring-summer to centers of abundance in the New York Bight and Southern New England. They migrate south in the autumn-winter as far a southeastern Florida. The bluefish is presently managed as a single stock although there is evidence of separate spawning events. However, recent data suggests that the reproductive pattern of bluefish is complex and support the concept of a single migratory spawning stock (Hare and Cowen 1993).

Habitat Characteristics by Lifestage

Eggs and larvae of bluefish are pelagic and are not commonly found in Long Island Sound, Peconic Estuary, or Block Island Sound. Pelagic-juveniles are transported, in May, inshore and by June they occur in the Middle Atlantic Bight between the shore and shelf/slope front. Juveniles occur in estuaries, bays, and the coastal ocean including Long Island Sound and Block Island Sound. Juveniles begin to depart Middle Atlantic Bight estuaries in October and migrate south to spend the winter months south of Cape Hatteras. Adult bluefish occur in the open ocean, large embayments, and most estuarine systems within their range which includes Long Island Sound and Block Island Sound (Oliver *et al*. 1989).

Distribution & Occurrence in Long Island Sound

Bluefish have become relatively abundant in Long Island Sound in recent years, especially in the fall (ENSR 2001). Juvenile and adult bluefish were captured frequently in CTDEP trawls surveys from July to October (Gottschall *et al.* 2000). In both Long Island Sound and Block Island Sound, bluefish are found over sandy, muddy, and/or silty substrate. Bluefish adults begin to appear in Long Island Sound during May when temperature preferences are 9-18°C. Abundance is highest during mid-summer on the Connecticut side of the Sound in depths <18 m. Peak abundance is reached during September when bluefish are found throughout the Sound (94% juvenile). Most bluefish collected in Hudson-Raritan estuary were juveniles (<35cm). There are no occurrences during winter and only a few adults were collected during spring. Adults were rarely collected during summer and autumn in a survey of Narragansett Bay. Most were collected in depths of 6-21 m (summer) and 9-43 m (autumn) and at bottom water temperatures of 15-26°C (summer) and 17-21°C (autumn).

3.12 FOURSPOT FLOUNDER (*PARALICHTHYS OBLONGUS*)

Designated Lifestages

Block Island Sound, Long Island Sound and the Peconic Estuary are not considered to be essential fish habitat for any life stage of this species, however, fourspot flounder are found in Long Island Sound and Block Island Sound. Juveniles and adults are the only life stages that would be associated with these Sounds. Eggs and larvae develop offshore.

Biology & Distribution

The following summary of fourspot flounder biology and distribution is adapted from Gottschall *et al.* (2000) and from fishbase.org.

Fourspot flounder are similar to summer flounder in size and shape except the fourspot possess four large dark spots encircled by faint pinkish rings on the body. Fourspot flounder inhabit inshore waters of Massachusetts, Connecticut, Rhode Island, and New York during the warmer times of the year. Fourspot prefer eelgrass beds and pilings because of the protection they offer. In the summer, small and medium sized adults are found on the sandy and muddy bottoms of bays, harbors and along open coastline. Most of the larger fish tend to stay in deeper waters. With the approach of fall, fourspot flounder migrate to more offshore waters in depths from 46 to 152 m.

Reproduction takes place in the fall, as soon as the fish start to migrate to wintering grounds. Peak spawning activity takes place from early September to early November in water temperatures from 53 to 66 degrees and in depths of 18 to 48 m. The center of spawning activity takes place off New York and New Jersey.

The eggs float in the water column, hatching 72 to 75 hours after being laid. After hatching, the larvae are carried into bays and estuaries where they will spend the early portions of their lives. Autumn water circulation patterns, in southern New England, tend to distribute surviving larval fish southward along the coast, resulting in the virtual absence of young fourspot flounder.

The fourspot flounder, which depends on sight to capture its' food, feeds most actively during daylight hours. Juveniles feed upon small shrimp and other crustaceans, while adults eat a variety of fish, including small winter flounder, menhaden, sand lance, red hake, silversides, bluefish, weakfish, mummichogs, as well as invertebrates such as blue crabs, squid, sand shrimp, shrimp, and mollusks. Adults are opportunistic predators and these fish are preyed upon by a number of other fish species and birds.

Habitat Characteristics by Lifestage

Fourspot flounder adults prefer mud bottom to transitional or sandy habitats. Eggs are spawned and buoyant, larvae develop in estuaries associated with structured habitat such as eelgrass beds that affords them protection from predators.

Distribution & Occurrence in Long Island Sound

Fourspot flounder are relatively abundant in Long Island Sound, especially in spring (ENSR 2001). Adults comprised about 85% of fourspot flounder taken from April through June, 76% in August, and 16% in October (Gottschall *et al.* 2000). Abundance increased rapidly during the spring period to a peak in June, and then quickly decreased through summer to a low level during the fall period that was similar to abundance in April. During May through November, the percent occurrence varied less than did abundance, ranging from 44% in September to 79% in June. Fourspot flounder were found throughout the Sound on all bottom types and depths, but were most abundant in the Central and Western Basins. Preferences for depth and bottom type within these basins were most pronounced during the months of highest abundance. Fourspot flounder were found mostly on mud bottom with abundance over transitional and sand bottoms ranking second and third respectively.

3.13 HOGCHOKER (*TRINECTES MACULATUS*)

Designated Lifestages

Neither Block Island Sound nor Long Island Sound are listed to have essential fish habitat for any life stage of this species. Hogchoker are rarely found in Long Island Sound and Block Island Sound as reported by Gottschall (2000).

Biology & Distribution

The following summary of hogchoker biology and distribution is adapted from Gottschall *et al.* (2000) and www.fishbase.org. Hogchoker have small eyes located on the right side of the head; body oval shaped; preopercular margin covered with skin and scales; dorsal and anal fin rays not connected to the caudal fin. They can be found, as adults, both in fresh and marine waters. The color pattern is highly variable and rapidly changeable; the right side is brownish gray with 7-8 black vertical lines and a number of small to large spots. The left side is usually plain white/pale brown, but sometimes has the same pigment as the right side. Hogchoker spawning occurs from May to September in inshore waters and estuaries. Young-of-year migrate upstream and congregate on mud flats. Hogchoker females can release between 11,075 to 54,000 eggs depending on size. Larvae are 1.7-1.9 mm at hatching and adults grow to a maximum of 20 cm TL (8 in.). Sharks, rays and other fish are predators of the hogchoker. This species of fish feeds on crustaceans, polychaetes, and shrimp and is an opportunistic feeder. Hogchoker prefer warmer water and have their greatest abundances in southern U.S. This species is commonly found in the Gulf of Mexico and it is rarely found in Long Island Sound or Block Island Sound.

Habitat Characteristics by Lifestage

Adults prefer shallow coastal waters over mud, silt, or sand in bays and estuaries. They occasionally inhabit fresh water. Juveniles can migrate upstream as far as 70 miles. Eggs are spherical and range in size from 0.89-0.94 mm. Both eggs and larvae are buoyant. Larvae range from 1.93 to 2.08 mm total length.

Distribution & Occurrence in Long Island Sound

Hogchoker are not abundant in Long Island Sound, the highest abundance in CTDEP trawls was 3 per tow in spring 1993 (ENSR 2001). Hogchoker exhibited a seasonal inshore/offshore pattern of distribution (Gottschall *et al.* 2000). During April, a month of low abundance, hogchoker were distributed in all depths in the Central and Western Basins. From May to June abundance was high in shallow water along the Connecticut shoreline from Norwalk to New Haven, and hogchoker were also found along the north shore of Long Island near Shoreham and Eaton's Neck. During July, when abundance was again low, hogchoker were still found along the Connecticut shore from Milford to New Haven, but they were rare along the Long Island shore, and none were observed in depths greater than 27 m.

Hogchoker abundance in deeper water increased from August through November, and by October they were concentrated along the Long Island side of the Western and Central Basins in depths greater than 18 m on mud and transitional bottoms (Gottschall *et al.* 2000). The most abundant catches occurred during October in this area. In November, a month of high abundance, they were most abundant in depths greater than 18 m on mud and transitional bottoms with none taken in depths less than 9 m.

3.14 KING MACKEREL (*SCOMBEROMORUS CAVALLA*), SPANISH MACKEREL (*SCOMBEROMORUS MACULATUS*), COBIA (*RACHYCENTRON CANADUM*)

Designated Lifestages

King mackerel, Spanish mackerel and cobia are all treated under the same essential fish habitat designation. Long Island, Block Island Sound and the Peconic Estuary system are all considered essential fish habitat for these three species, for all life stages (NOAA 1998). However, all three species are not found in great abundances in either Block Island Sound, Long Island Sound or the Peconic Estuary.

Biology & Distribution

Essential fish habitat for these coastal migratory pelagic species include sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters, from the surf to the shelf break zone, but from the Gulf Stream shoreward, including *Sargassum.* In addition, all coastal inlets, all state-designated nursery habitats are of particular importance to coastal migratory pelagics.

King Mackerel. The largest mackerel in the western Atlantic, the king mackerel is a prized gamefish and an important commercial species, with millions of pounds of fish landed annually. The streamlined body of the king mackerel is a dark gray above, growing silver on the sides and below, and there are no markings on the body, although the back may have an iridescent blue to olive tint. The king mackerel is usually 0.5 to 1 m long and weighs up to 20 pounds. It reaches a maximum length of 2 m and a weight of 100 pounds. Females grow larger than males. This species is believed to reach 14 years old, but those older than 7 years are rare. Male king mackerel become sexually mature between their second and third years, and female fish between their third and fourth years. They spawn from April through November, and activity peaks in late summer and early fall. A large female may spawn 1 to 2 1/2 million eggs. King mackerel feed mainly on fish, as well as on a smaller quantity of shrimp and squid.

Spanish Mackerel. The slender, elongated body of the Spanish mackerel is silvery with a bluish or olive green back. The Spanish mackerel resembles both the cero mackerel and the king mackerel but it has bronze or yellow spots without stripes. The Spanish mackerel grows to 93 cm and 11 pounds, averaging 0.5 to 1.0 m and 2 to 3 pounds. Fish older than five years are rare, although some have been known to reach eight years. Spanish mackerel feed primarily on small fish, as well as on squid and shrimp; they often force their prey into crowded clumps and can push the fish out of the water as they feed.

Cobia. Cobia is the only known member of the Rachycentridae family. Although juveniles are sometimes found in schools, adult cobia often swim alone or among small schools of sharks. They are believed to spawn in the offshore waters of the northern Gulf of Mexico during late spring and summer, between April and May, and the larvae migrate shoreward. Males reach sexual maturity when they are two years old

and 60 cm long, and females mature around 91 cm in length. An adult female cobia may lay 6 to 7 million eggs at one time. Juveniles are abundant in summer along coastlines after the spawning season. Cobia migrate from offshore to inshore environs as well as inshore from east to west and vice versa. Little about their movements has been confirmed, although it is known that in winter some fish move from shallow to deeper water, or laterally to warmer areas. A tagged cobia migrated 1,300 nautical miles from west of the Mississippi River to Daytona Beach, Florida, in an eight-month period. In the western Atlantic cobia migrate as far north as Cape Cod in the summer and then south again to tropical waters in the fall. Cobia feed mostly on crustaceans, particularly shrimp, squid, and crabs, as well as on eels and various small fish found in shallow coastal waters. Adult cobia may be preyed upon by tuna and sharks.

Habitat Characteristics by Lifestage

Essential fish habitat for eggs, larvae, of cobia, Spanish mackerel and king mackerel include sandy shoals of capes and offshore bars, rocky bottom and barrier island oceanside waters from the surf to the shelf break zone, as well as high salinity bays, estuaries, and eelgrass beds.

Adult cobia prefer shallow continental shelf waters, often congregating along reefs and around buoys, pilings, wrecks, anchored boats, and other stationary or floating objects. They are found in a variety of locations over mud, gravel, or sand bottoms, coral reefs and man-made sloughs, and at depths of up to 18 m.

King mackerel adults are primarily an open-water, migratory species, preferring warm waters that seldom fall below 68°F. They often occur around wrecks, buoys, coral reefs, ocean piers, inlets, and other areas where food is abundant. They tend to avoid highly turbid waters, and larvae are often found in warm, highly saline surface waters. A schooling species, king mackerel migrate extensively and annually along the western Atlantic coast in schools of various sizes, although the largest individuals usually remaining solitary, thus limiting the presence of this species in Long Island Sound and Block Island Sound to the summer season.

In the western Atlantic, there are two separate populations of Spanish mackerel: one in the Gulf of Mexico and the other along the main western Atlantic coast. The former extends from the Gulf of Mexico throughout Florida waters to the Yucatán, and the latter extends from Miami to the Chesapeake Bay and occasionally to Cape Cod. They are absent from the Bahamas and the Antilles, except around Cuba and Haiti, but are abundant around Florida. Therefore, Spanish mackerel are rarely found in Long Island Sound or Block Island Sound.

Distribution & Occurrence in Long Island Sound

Gottschall *et al.* (2000) did not include a summary of cobia or king mackerel in the Connecticut (CTDEP) bottom trawl survey but does include information on Spanish mackerel. Spanish mackerel were first

observed in the CTDEP bottom trawl survey in 1989. They were relatively uncommon, occurring in 3.9% of samples in September, 1.6% in October, and 1.9% in November. They ranged in size from 8-54 cm. Most of the Spanish mackerel were taken in depths less than 18 m in several neashore areas including Smithtown Bay, near Shoreham, NY and between Norwalk and New Haven, CT.

Since cobia, Spanish mackerel, and king mackerel are all considered south Atlantic species for essential fish habitat purposes (NOAA 1998) these species would not be found in Long Island Sound or Block Island Sound with any great abundance.

3.15 POLLOCK (*POLLACHIUS VIRENS*)

Designated Lifestages

All of Long Island Sound, the inner reaches of the Peconic Estuary and all of Block Island Sound are considered essential fish habitat for juvenile and adult pollock (NOAA 1998).

Biology & Distribution

The following summary of pollock biology is adapted from Gottschall *et al.* (2000) and Cargnelli *et al.* (1999). Pollock is a gadoid species inhabiting both sides of the North Atlantic. In the Northwest Atlantic they are most common on the Scotian Shelf, Georges Bank, in the Great South Channel, and in the Gulf of Maine. However, juveniles and adults can be found closer to shore. This species is assessed and managed as a single stock.

Pollock eggs are buoyant and can be found in the water column. The pelagic larval stage lasts for three to four months at which time the small juveniles migrate inshore where they inhabit rocky subtidal and intertidal zones. They undergo a series of inshore-offshore movements linked to temperature (Ojeda and Dearborn 1990) until the end of their second year and then move and remain offshore through their adult stage.

Adult pollock can attain maximum lengths of 120 cm but are usually less than 110 cm. A maximum age of 18 years has been recorded although the major portion of the catch consists of 3-6 year old fish (Mayo, 1994). Growth is rapid until sexual maturity. Pollock are schooling species and are found through the water column. Pollock adults are fairly stationary in the Gulf of Maine and along the Nova Scotian coast (Hardy 1978).

The principal pollock spawning sites in the northwest Atlantic are in the western Gulf of Maine, Great South Channel, Georges Bank and on the Scotian Shelf. Spawning takes place from September to April. In the gulf of Maine spawning occurs from November to February (Steele 1963). Spawning occurs over

hard, stony or rocky bottom when the water column cools to near 8°C and peaks when temperatures are 4.5-6°C.

Pollock feed on pelagic prey. The primary prey of small larvae are larval copepods while larger larvae feed on adult copepods. Juvenile pollock feed on crustaceans such as euphausiids. Fish and mollusks make up a smaller portion of the juvenile diet. The diet of adults is comprised of euphausiids, fish and mollusks (Steele 1963). It is likely that sharks prey upon adult pollock, as do other gadoid species. Juvenile, larvae, and eggs are preyed upon by multiple fish species.

Habitat Characteristics by Lifestage

Pollock eggs are spawned over broken substrate and rocky bottoms. The eggs are pelagic and free floating in the water 50-250 m deep. Larvae are also pelagic, commonly found at temperatures of 3-9°C (Bigelow and Schroeder 1953) and normally occur from the shore to the 200 m depth contour. Juveniles have been recorded over a wide variety of substrates including sand, mud or rocky bottom and vegetation (Hardy 1978). They are found at temperatures ranging from 0-16°C. Inshore subtidal and intertidal zones are utilized by age 0+ and 1+ juveniles and serve as important nursery areas. Age 2+ juveniles move offshore. Adults show little preference for bottom type and are found at temperatures of 0-14°C (Hardy 1978). They inhabit a wide range of depths, 35-365 m, but most occur within the 200 m depth contour. Adults tend to inhabit deeper waters in spring and summer than in winter and they are typically found further offshore than juveniles (Mayo *et al.* 1989).

Distribution & Occurrence in Long Island Sound

Since eggs and larvae are not found in Long Island Sound, Block Island Sound or the Peconic Estuary system only the distribution and occurrence of the juvenile and adult stages are reported here. A total of only 336 pollock juveniles were caught in Narragansett Bay from 1990-1996 (Reid *et al.* 1990). They were caught in all seasons but the majority was caught in the spring. Pollock are not commonly caught in the surveys of the Long Island Sound and none have been recorded since 1989 (Gottschall *et al.* 2000). In surveys conducted from 1984-1990 throughout Long Island Sound, just 24 juveniles were caught. All were caught during summer at all depths and bottom types except sand. No adults were caught during these years or have been since caught in Long Island Sound, however, NOAA (1998) lists Long Island Sound as an essential fish habitat for juvenile and adult stages of this species. The lifestages of this species prefer offshore habitat.

3.16 RED HAKE (*UROPHYCIS CHUSS*)

Designated Lifestages

All of Long Island Sound is considered as essential fish habitat for all life stages of red hake. The Peconic Estuary and Block Island Sound are essential fish habitat for only eggs, larvae, and juvenile red hake.

Biology & Distribution

The following summary of red hake biology is adapted from Gottschall *et al.* (1999) and NOAA Technical Memorandum NMFS-NE-133 (1999b). Adult red hake are common on mud but can also be found in the water column. There are two managed stocks: a northern stock from the Gulf of Maine to northern Georges Bank and a southern stock, from southern Georges Bank into the Middle Atlantic Bight (Cape Hatteras to Nantucket Shoals). Red hake adults make extensive seasonal, depth and temperature related migrations. They are most common in depths <100m during warmer months and in depths >100m during colder months. In the Middle Atlantic Bight, including Long Island Sound, red hake occur most frequently in coastal waters in the spring and fall. They move offshore in the summer to avoid the warm water temperatures (Bigelow and Schroeder 1953). Occasionally, juveniles can be found in the nearshore, deeper channels during summer months.

Juvenile red hake are sensitive to dissolved oxygen (DO) levels <4.2 mg/L. In laboratory experiments they left their bottom shelter and ascended into the water column increasing their risk to predation (Bejda *et al.* 1987). Older fish are less sensitive to lower DO levels. Shelter is a critical habitat requirement for red hake (Steiner et al 1982). Newly settled juveniles occur in depressions on the open seabed (Able and Fahay, 1998). Older juveniles commonly associate with shelter or structure, often with living sea scallops (*Placopecten magellanicus*) where they can be found under the scallops on the sediment or within their open mantle cavity (Steiner *et al.* 1982; Garman 1983; Able and Fahay 1998). Juveniles maintain this association until they are about 10-13 cm total length.

Larvae are planktonic and have been collected on southern Georges Bank and on the mid- to outer continental shelf throughout the Middle Atlantic Bight. Larvae are most abundant during the early fall. Red hake larvae dominate the summer ichthyoplankton in the Middle Atlantic Bight and have been also reported in the marine parts of several bays and estuaries including Narragansett Bay, Buzzards Bay, the Hudson-Raritan Estuary and in bays north of Cape Cod to the Merrimack River, New Hampshire.

The pelagic eggs of red hake are not separated from eggs of similar species in field collections, thus the characteristics of the habitat in which red hake eggs are commonly found are poorly known. Based on

eggs taken from spawning red hake, the eggs are about 0.6-1.0 mm in diameter, buoyant, and float near the surface. Hatching occurs in 3-7 days.

Larvae prey mainly on copepods and other mirocrustaceans. Juvenile red hake leave shelter at night and commonly prey on small benthic and pelagic microcrustaceans. Adult red hake, like juveniles, prey upon crustaceans but also consume a variety of demersal and pelagic fish and squid (Langton and Bowman 1980). The diet of red hake overlaps the diet of the two other *Urophycis* spp. in the New York Bight.

Habitat Characteristics by Lifestage

Adult red hake occur on muddy sediment but can be found in the water column. Recently metamorphosed juveniles remain pelagic until they reach 25-30 mm total length (TL). Demersal settlement generally occurs between September and December with peaks in October-November. Adults are most abundant in the central portion of Long Island Sound from April through June.

Spawning occurs in the summer on the continental shelf of the Middle Atlantic Bight and is concentrated off southern New England (Able and Fahay, 1998). Juvenile red hake distribution from the CTDEP trawl survey was compared with the sediment distribution in Reid *et al.* (1979) and suggested that red hake juveniles prefer silty, fine sand sediments. Older juveniles commonly associate with shelter or structure (e.g. depressions in seabed) or within the open mantle cavity of bivalves, particularly sea scallops.

Distribution & Occurrence in Long Island Sound

Red hake are relatively abundant in CTDEP trawls especially in spring (ENSR 2001). Juvenile and adult red hake were captured frequently in CTDEP trawls surveys from April to August. Captured red hake ranged in length from 7 to 53 cm (Gottschall *et al.* 2000). In both Long Island and Block Island Sound, red hake are found over muddy substrate.

The majority of red hake collected in April and May were adults while juveniles (young-of-the-year and 1+) dominated red hake catches in the summer and fall. Some of the largest catches occurred during the spring and summer in three locations: north of Shoreham, NY across the Sound to south of Milford.

3.17 SCUP (*STENOTOMUS CHRYSOPS*)

Designated Lifestages

Essential fish habitat is designated for egg, larval, juvenile, and adult life stages of scup in all of Long Island Sound, Block Island Sound, and the Peconic Estuary.

Biology & Distribution

The following summary of scup biology is adapted from Steimle *et al.* (1999). Adult scup occur in the Middle Atlantic Bight (Cape Hatteras to Nantucket Shoals) from spring to fall and may be found over sandy areas or among structured habitats. Smaller-sized adult scup are common in larger bays and estuaries while larger-sized fish tend to occur in deeper waters. Most juvenile and adult scup migrate to the Continental Shelf in the fall and return to inshore waters in the spring.

Scup spawning occurs between May and August, peaking in June. Most spawning occurs outside estuaries but not over the continental shelf in southern New England, including eastern Long Island Sound and much of Block Island Sound. Newly hatched scup larvae are pelagic and begin exogenous feeding at approximately 2.8 mm total length (TL). By early July, scup larvae reach 15-30 mm TL and become demersal in shoal waters. Juvenile scup reach sizes of 5 to 10 cm fork length (FL) by November.

Scup feed primarily from spring to fall and exhibit reduced feeding and growth in winter. Larval scup are thought to feed on small zooplankton. In Long Island Sound and Block Island Sound, scup juveniles feed during the day, primarily on polychaetes, epibenthic amphipods and other small crustaceans, mollusks, and fish eggs and larvae. Post-larval and juvenile scup consume copepods and mysids while adults feed on small crustaceans, polychaetes, mollusks, small squid, insect larvae, hydroids, sand dollars, and small fish.

Some adult and juvenile scup remain in large, deep estuaries during warmer winters yet most overwinter along the mid-continental shelf. Offshore migration is triggered by water temperatures declining below 8^{o} or 9^{o}C. As water temperatures rise in early spring, offshore wintering scup return to inshore waters.

Habitat Characteristics by Lifestage

Adult and juvenile scup occur in intertidal and subtidal habitats, over sand, silty-sand, shell, mud, mussel beds and eelgrass. Richards (1963) reported that juvenile scup were more common over sandy habitats approximately 9 meters deep rather than in deeper, muddy habitats. Scup are generally limited to water temperatures between 7-27°C.

Scup eggs, which are pelagic, are most abundant in nearshore areas with depths less than 50 meters. Eggs are common to abundant in the more saline parts of large estuaries and bays (>25ppt) in southern New England from May to August, with peak abundances recorded in June and July (Able and Fahay 1997). Larval scup are commonly collected in euryhaline habitats and at depths less than 50 m. In summer and fall, young-of-the-year and 1+ scup may be found in tidal bays, sounds and coastal areas north of Chesapeake Bay at depths less than 38 m. Juvenile scup are most abundant from the intertidal zone out to 30 m.

Distribution & Occurrence in Long Island Sound

Scup are highly abundant in Long Island Sound in spring and fall, with fall catches increasing dramatically in recent years (ENSR 2001). Scup were found in all habitats during both seasons. Captured scup ranged in length from 3 to 39 cm (Gottschall *et al.* 2000). Scup were found over mixed sand and mud substrate.

The majority of scup collected in April and May were adults while juveniles (young-of-the-year and 1+) dominated scup catches in the summer and fall. Age 1+ scup were collected at all depths and over transitional and sand bottoms. Some of the largest catches occurred during the summer and fall in three locations: south of Milford, near the Thames River, and in Niantic Bay. Juvenile scup were more dispersed in the fall; most age 1+ scup were collected in depths greater than 18m and over transitional bottom south of Guilford. Young-of-the-year scup were collected in Long Island Sound from August to November with peak abundance in the fall. Young-of-the-year scup were concentrated over mud and transitional bottom near Niantic Bay, along the Mattituck Sill, north of Shoreham, and throughout the Western Basin. Like older juveniles, young-of-the-year scup were most abundant at depths greater than 18 m in the November trawl surveys.

Similar patterns of spatial and temporal distribution have been reported for scup in Rhode Island (Mike Ludwig, National Marine Fisheries Service, personal communication, 2001).

3.18 SILVER HAKE (*MERLUCCIUS BILINEARIS*)

Designated Lifestages

Central and eastern Long Island Sound are considered essential fish habitat for silver hake adults, only (i.e. whiting). The Peconic Estuary is considered essential fish habitat for all stages of silver hake. Block Island Sound is considered essential fish habitat for eggs, larvae, and juveniles only for this species.

Biology & Distribution

The following summary of silver hake biology is adapted from Gottschall *et al.* (1999) and NOAA Technical Memorandum NMFS-NE-135 (1999). Silver hake, *Merluccius biinearis*, are distributed on the Continental Shelf of the northwest Atlantic Ocean from Cape Fear, North Carolina (Karnella 1973) to the Gulf of St. Lawrence and the southern edge of the Grand Banks, Newfoundland, Canada (Leim and Scott 1966). Silver hake are slender, fast swimming gadoids that are often found in dense schools associated with specific hydrographic conditions, prey concentrations and spawning requirements. Analyses of bottom trawl catches in U.S. waters show that adult silver hake are found throughout their range in winter and spring but are concentrated in deep basins in the Gulf of Maine and along the Continental Slope from Nova Scotia to Cape Hatteras (Helser, 1995). In U.S. waters, two stocks of silver hake have been

identified based on morphometric differences. One stock occurs in the Gulf of Maine to northern Georges Bank while the other stock ranges from southern Georges Bank to Cape Hatteras. Juveniles and adults migrate to deeper waters of the Continental Shelf as water temperatures decline in the autumn and return to shallow waters in spring and summer to spawn. Major spawning areas are coastal Gulf of Maine, southern Georges Bank, and waters south of Rhode Island. Silver hake reach sexual maturity at 2-3 years and live a maximum of 15 years although in recent years few fish older than 6 years have been caught.

Adult silver hake are common on mud but can also be found in the water column. There are two managed stocks: a northern stock from the Gulf of Maine to northern Georges Bank and a southern stock, from southern Georges Bank into the Middle Atlantic Bight (Cape Hatteras to Nantucket Shoals). Silver hake adults make extensive seasonal, depth and temperature related migrations. They are most common in depths <100m during warmer months and in depths >100m during colder months. In the Middle Atlantic Bight, including Long Island Sound, silver hake occur most frequently in coastal waters in the spring and fall. They move offshore in the summer to avoid the warm water temperatures (Bigelow and Schroeder 1953). Occasionally, juveniles can be found in the nearshore, deeper channels during summer months.

Juvenile silver hake are sensitive to dissolved oxygen (DO) levels <4.2 mg/L. In laboratory experiments, under low DO conditions, they left their bottom shelter and ascended into the water column increasing their risk to predation (Bejda *et al.* 1987). Older fish are less sensitive to lower DO levels. Shelter is critical habitat requirement for silver hake (Steiner et al 1982). Newly settled juveniles occur in depressions on the open seabed (Able and Fahay, 1998). Older juveniles commonly associate with shelter or structure, often with living sea scallops (*Placopecten magellanicus*) where they can be found under the scallops on the sediment or within their open mantle cavity (Steiner *et al.* 1982; Garman 1983; Able and Fahay 1998). Juveniles maintain this association until they are about 10-13 cm total length.

Larvae are planktonic and have been collected on southern Georges Bank and on the Mid- to Outer-Continental Shelf throughout the Middle Atlantic Bight. Larvae are most abundant during the early fall. Silver hake larvae dominate the summer ichthyoplankton in the Middle Atlantic Bight and have been also reported in the marine parts of several bays and estuaries including Narragansett Bay, Buzzards Bay, the Hudson-Raritan Estuary and in bays north of Cape Cod to the Merrimack River, New Hampshire.

The pelagic eggs of silver hake are not separated from eggs of similar species in field collections, thus the characteristics of the habitat in which silver hake eggs are commonly found are poorly known. Based on eggs taken from spawning silver hake, the eggs are about 0.6-1.0 mm in diameter, buoyant, and float near the surface. Hatching occurs in 3-7 days.

Larvae prey mainly on copepods. Juvenile silver hake leave shelter at night and commonly prey on small benthic and pelagic microcrustaceans. Adult silver hake, like juveniles, prey upon crustaceans but also consume a variety of demersal and pelagic fish and squid (Langston and Bowman 1980). The diet of silver hake overlaps the diet of the two other *Urophycis* spp. in the New York Bight.

Habitat Characteristics by Lifestage

Based on the Northeast Fisheries Science Center bottom trawl survey, silver hake were distributed across the shelf in northern Middle Atlantic Bight and southern New England areas, along the southern and northern edges of Georges Bank, and scattered throughout the Gulf of Maine in the winter. In the spring, they occurred throughout the survey area but tended to avoid the shallowest parts of the Middle Atlantic Bight and Georges Bank. Concentrations occurred in relatively deep waters of southern New England along the southern and northern edges of Georges Bank, and in the western part of the Gulf of Maine. The Hudson-Raritan estuary trawl survey caught just one adult silver hake in January 1995. Results of the Rhode Island trawl survey showed that, in general, low numbers of silver hake occurred throughout Narragansett Bay. Adult silver hakes occurred throughout Narragansett Bay in small numbers in all seasons.

Adult silver hake occur on muddy sediment but can be found in the water column. Recently metamorphosed juveniles remain pelagic until they reach 25-30 mm-total length (TL). Demersal settlement generally occurs between September and December with peaks in October-November. Adults are most abundant in the central portion of Long Island Sound from April through June.

Spawning occurs in the summer on the Continental Shelf of the Middle Atlantic Bight and is concentrated off southern New England (Able and Fahay, 1998). Juvenile silver hake distribution from the CTDEP trawl survey was compared with the sediment distribution in Reid *et al.* (1979) and suggested that silver hake juveniles prefer silty, fine sand sediments. Older juveniles commonly associate themselves with shelter or structure (e.g. depressions in seabed) or within the open mantle cavity of bivalves, particularly sea scallops.

Distribution & Occurrence in Long Island Sound

Silver hake were moderately abundant in Long Island Sound and were found at all temperatures sampled, except 23°C in autumn, and they showed no particular preference for temperature in either spring or autumn. Hake were captured at most depths sampled and showed no preference for particular depths in spring or autumn. Silver hake adults were captured throughout the range of salinities observed in the Long Island Sound. No clear salinity preference was evident in spring, but in autumn silver hake were captured at higher than average salinities. Captured silver hake ranged in length from 7 to 53 cm (Gottschall *et al.* 2000). In both Long Island Sound and Block Island Sound, silver hake were found over

muddy substrate. In Narragansett Bay, adult silver hakes were relatively abundant at depths >20 m in all seasons and showed a preference for bottom temperatures between 7 and 16°C. The catches of silver hake in Long Island Sound showed a high incidence of adults (>22 cm) in spring. Highest catches for the species occur within the Long Island Sound disposal site analysis area and along Stratford Shoal in the Western and Central Basins. This region consists of shallow and deep stations with mud bottoms (ENSR 2001). The majority of silver hake collected in April and May were adults while juveniles (young-of-the-year and 1+) dominated silver hake catches in the summer and fall.

3.19 SPOTTED HAKE (UROPHYCIS REGIA)

Designated Lifestages

The Peconic Estuary, Block Island Sound and Long Island Sound do not have essential fish habitat for any life stage of spotted hake.

Biology & Distribution

The following summary is based on the information presented in Gottschall *et al.* (2000) and http://www.fishbase.org.

Spotted hake are distributed throughout the Northwest Atlantic from southern New England to the northeast coast of Florida. This species can also be found in the northeastern Gulf of Mexico. The head of spotted hake is marked with a series of dark spots and the opercula have a dusky blotch. The first dorsal fin has a dark blotch and a distinct white margin. Spotted hake are found onshore, most commonly between 110 and 185 m. Spotted hake feed on crustaceans, and possibly fish and squids. Juveniles of this species spend part of their time in estuaries. Adults can reach a total length of 41.0 cm. They are strictly demersal and marine. Their depth ranges from 9m to 420 m (Langton and Bowman, 1980). Predators include sharks and skates.

Habitat Characteristics by Lifestage

Eggs are buoyant and are approximately 0.70 mm. Development time is 2.38 days at 22.5°C. Adults move inshore during the summer months and then migrate to deeper, offshore waters during the winter and spring to spawn. Larvae are also buoyant, mature to juvenile stages and then move inshore to estuarine water. Juveniles and adults prefer transitional or sandy bottom habitat.

Distribution & Occurrence in Long Island Sound

Gottschall *et al.* (2000) report that 1,427 spotted hake were caught in 2,859 tows between 1984-1994 during the CTDEP trawl surveys. Spotted hake were taken in every month of the survey, with percent

occurrence ranging from 1.9% in April to 21.6% in October. Spotted hake abundance was lowest in April, increased through October, and then declined slightly in November.

During spring and summer, spotted hake were found primarily in the Central and Western Basins. However, in spring, abundance was highest in depths less than 18 m, whereas during the summer period abundance increased in depth greater than 18 m. When abundance was highest from September through November, the distribution of spotted hake changed; they were most abundant over the transitional and sand bottoms of the Mattituck Sill and adjacent portions of the Central Basin, and in the Eastern Basin. During October, the month of peak abundance, spotted hake were most abundant in depths greater tan 18 m. Spotted hake were also common in Smithtown Bay, CT near the mouth of the Connecticut River.

3.20 STRIPED BASS (*MORONE SAXATILIS*)

Designated Lifestages

Neither Block Island Sound nor Long Island Sound are listed to have essential fish habitat for any life stage of this species. However, striped bass are found in Long Island Sound as reported by Gottschall *et al.* (2000), but they are not very common.

Biology & Distribution

The following summary is based on the information presented in Gottschall *et al.* (2000), http://www.fishbase.org and the Angler's Encyclopedia at

http://www.kenschultz.com/template2.asp?fishname=Sturgeon,%20Atlantic.

Striped bass are a large fish with a large mouth and are similar in size to the white bass. This species has a long body and long head, a somewhat laterally compressed body form, and a protruding lower jaw. The striped bass also has a forked tail and small eyes. These fish are mostly bluish black or dark green above, fading into silver on the sides and white on the belly. On each side of its body, there are seven or eight prominent black horizontal stripes that run along the scale rows that are the distinctive markings of the striped bass; one of the stripes runs along the lateral line, and the rest is equally divided above and below it. The stripe highest up on the side is usually the most noticeable, although on some fish, one or more of the stripes is interrupted. Most of the fins are dusky silver, with the exception of the white pelvic fins. The young, of less than 10.1 cm long as well as the breeding adults, have 8 to 10 dark vertical bars that are more apparent than the horizontal stripes. The vertical bars disappear as the fish mature (Fay *et al.* 1983).

Although this species has a natural range from the Gulf of St. Lawrence to the Gulf of Mexico, it has been successfully introduced elsewhere. Being anadromous, striped bass live in coastal and estuarine areas and enter fresh or low salinity waters for spawning. Eggs and larvae develop in the fresh or low salinity water, as well. Migratory and non-migratory stocks exist, with the former predominating in the mid-Atlantic. Most of the mid-Atlantic fish originate in Chesapeake Bay (Fay *et al.* 1983). The Hudson River also has an important spawning stock. Migrating stripers move north in the spring, spawn in low salinity waters, and then resume their northward coastal migration. The return migration occurs in the fall, and individuals overwinter in coastal areas from New Jersey to North Carolina, and in Chesapeake Bay.

Striped bass males are sexually mature by their second or third year, whereas females are sexually mature sometime between their eighth and ninth years; males measuring at least 7.18 cm, and females as small as 86 cm, are known to spawn (Fay *et al.* 1983). Spawning occurs in fresh or slightly brackish waters from mid-February in Florida to late June or July in Canada, when the water temperature is between 10° to 23°C; peak spawning activity is observed between 15°C and 20°C. They prefer the mouths of freshwater tributary streams, where the current is strong enough to keep the eggs suspended. Females can carry 180,000 to 4.5 million eggs, depending on their size. When mating, each female is accompanied by several smaller males. The spawning fish swim near the surface of the water, turning on their side and rolling. The semi-buoyant eggs are released and drift with the current until they hatch two to three days later, depending on the water temperature (Fay *et al.* 1983).

The young move downstream to the estuarine portions of rivers in the late summer or early fall. As young and as adults, striped bass move in schools, except for larger fish, which either travel alone or with a few others of similar size (Fay *et al.* 1983). Most striped bass along the Atlantic coast are involved in two types of migrations: an upriver spawning migration from late winter to early spring, and coastal migrations that are apparently not associated with spawning activity. Coastal migrations can be quite extensive; striped bass tagged in the Chesapeake Bay have been recaptured in the Bay of Fundy. Coastal migratory behavior in the Atlantic appears to be limited to stocks north of Cape Hatteras and is related to sex and age (Fay *et al.* 1983).

A voracious, carnivorous, and opportunistic predator, the striped bass feeds heavily on small fishes, including large quantities of herring, menhaden, flounder, alewives, silversides, eels, and smelt, as well as invertebrates such as worms, squid, and crabs. Young striped bass feed on zooplankton and quickly graduate to freshwater shrimp and midge larvae (Fay *et al.* 1983). Freshwater striped bass prefer shad, herring, minnows, amphipods, and mayflies. Stripers are unlike some anadromous fish during their spawning run in that they will feed while migrating to their spawning grounds, although they reportedly cease feeding shortly before spawning.

Habitat Characteristics by Lifestage

Growing rapidly in early life, striped bass average 5 to 10 pounds, although they often reach weights in the 30- to 50-pound range. The maximum size that a freshwater striped bass can achieve is unknown, although the largest sport-caught freshwater striper weighed 59 pounds, 12 ounces. The all-tackle record for the species-78 pounds 8, ounces-belongs to a saltwater fish, although larger ones have been reportedly taken commercially. Striped bass normally live 10 to 12 years, although most fish more than 11 years old and more than 99 cm long are female. The largest striped bass ever reported was 125-pounds believed to be between 29 and 31 years old.

Striped bass inhabit saltwater, freshwater, and brackish water, although they are most abundant in saltwater. They are anadromous and migrate in saltwater along coastal inshore environs and tidal tributaries. They are often found around piers, jetties, surf troughs, rips, flats, and rocks. A common regional name for stripers is "rockfish", although they do not necessarily spend most of their lives in association with rocks. They run far upstream during spawning runs and are also found in channels of medium to large rivers at that time (Fay *et al.* 1983). The striped bass is entirely a coastal species off the coast of the Carolinas and southward, never ranging more than a few miles offshore; along the entire Atlantic coast, they are rarely caught more than a short distance from shore except during migration.

Distribution & Occurrence in Long Island Sound

Gottschall *et al.* (2000) report that only 514 striped bass were caught in 2,859 tows between 1984-1994 during the Connecticut trawl surveys. Striped bass were rarely found in Long Island Sound. The abundance of this species, in Long Island Sound, was highest in May and in November and lowest during the summer period. Only three striped bass were observed during July, and none were taken in August. During all seasons they were most commonly taken along the Connecticut and Long Island coastlines in depths less than 18 m over all bottom types, especially near the months of the Connecticut and Housatonic Rivers.

Striped bass taken in the CTDEP bottom trawl survey ranged from 11 to 126 cm. During the months of highest abundance a wide range of sizes were observed, with striped bass ranging from 11 to 91 cm in May and 20 to 75 cm in November. From June through October striped bass were primarily larger than 45 cm, with none smaller than 34 cm.

3.21 SUMMER FLOUNDER (*PARALICHTHYS DENTATUS*)

Designated Lifestages

All of Long Island Sound is designated to be essential fish habitat for summer flounder juveniles, only. Block Island Sound is designated essential fish habitat for adult summer flounder, only. The Peconic Estuary is designated essential fish habitat for larva, juvenile, and adult summer flounder.

Biology & Distribution

The following summary of summer flounder biology and distribution is adapted from the NOAA technical source document (Packer *et al.* 1999) and Gottschall *et al.* (2000). The geographical range of summer flounder encompasses the shallow estuarine waters and Outer Continental Shelf from Nova Scotia to Florida (Bigelow and Schroeder 1953; Grimes *et al.* 1989). The center of its abundance lies within the Middle Atlantic Bight (Middle Atlantic Bight) from Cape Cod, Massachusetts to Cape Hatteras, North Carolina. Summer flounder exhibit strong seasonal inshore-offshore movements, although their movements are often not as extensive as compared to other highly migratory species. Adult and juvenile summer flounder normally inhabit shallow coastal and estuarine waters during the warmer months of the year and remain offshore during the fall and winter (Grimes *et al.* 1989). Summer flounder is managed and assessed as a single stock by the Mid-Atlantic Fisheries Management Council.

Adult flounder normally inhabit shallow coastal and estuarine waters during the warmer months of the year and remain offshore during the colder months. Fish usually begin seaward migrations in September or October. The coastal waters of Rhode Island, the immediate waters surrounding Block Island, and the waters of Little Narragansett Bay and all of Narragansett Bay are habitat for both adults and juveniles. Adults were distributed in these habitats throughout Narragansett Bay and captured in all seasons except winter. In Connecticut waters, the flounder migrate to inshore waters in late April and early May, are present in Long Island Sound throughout the April-November trawl survey period, and probably occur in limited numbers in winter as well (Grimes *et al.* 1989). In the Hudson-Raritan estuary, New York and New Jersey, summer flounder was the 13th most abundant species. In the fall, they tend to be found in greater numbers in the deeper waters of the Raritan Channel. In the spring, the greatest numbers occurred in Sandy Hook Bay.

Spawning occurs over the open ocean areas of the Shelf. Summer flounder spawn during the fall and winter while the fish are moving offshore or onto their wintering grounds. The offshore migration is presumably keyed to declining water temperature. Spawning begins in September in the inshore waters of southern New England and the mid-Atlantic and continues through December.

Eggs of summer flounder are pelagic and buoyant. They are spherical with a transparent shell. Mean diameter of mature eggs is 0.98 mm. Eggs are most abundant between Cape Cod and Cape Hatteras. The heaviest concentrations of eggs have been reported within 45 km of shore off New Jersey and New York. Eggs are collected mostly at depths of 30-70 m in the fall and as far down as 110 m in the winter and from 10-30 m in the spring (Grimes *et al.* 1989).

Planktonic larvae are often most abundant 19-83 km from shore at depths around 10-70 m, and are found in the northern part of the Middle Atlantic Bight from September to February. From October to May larvae and postlarvae migrate inshore, entering coastal and estuarine nursery areas to complete transformation (Grimes *et al. 1989;* Able *et al.* 1990). They then leave the water column and settle to the bottom where they begin to bury in the sediment and complete development to the juvenile stage.

Juveniles are distributed inshore and in many estuaries throughout their range during spring, summer, and fall. In mid-Atlantic estuaries, first year summer flounder can grow rapidly and attain lengths of up to at least 30.0 cm. Juvenile summer flounder make use of several different estuarine habitats. Estuarine marsh creeks are important, seagrass bed, mud flats and open bay areas are utilized.

Habitat Characteristics by Lifestage

Eggs were most abundant in the water column where bottom temperatures were between 12 and 19°C. The rate of development is dependent on temperature, with development rate increasing as temperature increases. Larvae have been found in temperatures ranging from 0-23°C but are most abundant between 9-18°C. The prevailing temperature conditions influence the duration of metamorphosis of pelagic larvae with increasing temperatures resulting in a shorter metamorphic period. Summer flounder were dominant in sandy substrates or where there was a transition from fine sand to silt and clay. Larval and post larval summer flounder initially feed on zooplankton and small crustaceans. Juvenile estuarine summer flounder are opportunistic feeders and differences in diet are often related to the availability of prey. Larval and juvenile summer flounder are preyed upon until they grow large enough to fend for themselves. Typical predators include spiny dogfish, goosefish, cod, silver hake, red hake, spotted hake, sea raven, longhorn sculpin, and fourspot flounder (Bowman *et al.* 1976).

Adults have been reported as preferring sandy habitats (Bigelow and Schroeder 1953; Grimes *et al.* 1989). Adult summer flounder are opportunistic feeders with fish and crustaceans making up a significant portion of their diet. Differences in diet between habitats or locations may be due to prey availability. The flounder are most active during daylight hours and may be found well up in the water column as well as the bottom (Olla *et al.* 1972). Natural predators of adult summer flounder are not fully documented, but larger predators such as sharks, rays, and goosefish probably include summer flounder in their diets.

Distribution & Occurrence in Long Island Sound

Summer flounder were moderately abundant species in the CTDEP trawl surveys conducted in Long Island Sound; highest mean catches were between 59 and 75 fish per tow (ENSR 2001). Summer flounder abundance in the Sound increased in recent years. Summer flounder taken in the survey ranged from 12 to 76 cm. The percentage of juvenile fish decreased from 35% in April to 1.0% in August, but increased again to 13% in November.

Summer flounder were taken in all months of the survey, with percent occurrence ranging from 17.1% of samples in November to 63.2% in September. Abundance peaked twice - in May and September - with highest abundance in September. In April, abundance was similar in all depths, but from late spring through the summer period abundance tended to increase with decreasing depth. Summer flounder were evenly distributed in Long Island Sound during spring and fall, slightly more flounders were collected in shallow mud and transitional areas of the Western and Central Basins during the fall. During the summer period, summer flounder were particularly abundant along the Connecticut shore from Guilford to New Haven, off the Connecticut River, in Niantic Bay and near Mattituck, New York. By November, when abundance in the survey was lowest, the remaining summer flounder were primarily taken in deeper water.

3.22 TAUTOG (*TAUTOGA ONITIS*)

Designated Lifestages

There is no essential fish habitat designated for tautog. However, adults of this species can be found in both Block Island Sound and Long Island Sound.

Biology & Distribution

The following summary is based on the information presented in Gottshcall *et al.* (2000), http://www.fishbase.org and the Angler's Encyclopedia http://www.kenschultz.com.

The tautog is blunt-nosed and thick-lipped, it has a high forehead and a heavy body. It is brownish on the back and sides and lighter below, and it has blackish mottling over the entire body. The belly and chin are white or gray, and there may be spots on the chin. Females develop a white saddle down the middle of each side during spawning. The caudal fin is rounded on the corners and squared across the tip; the soft-rayed dorsal and anal fins are rounded. A number of small teeth are present along the sides of the jaws, and there are two to three large canine teeth in the tips (Auster 1989).

Tautog average 3 pounds or less in weight. Specimens weighing 6 to 10 pounds can be caught. The tautog occurs in the western Atlantic from Nova Scotia to South Carolina, and the greatest abundance is

between Cape Cod, Massachusetts and Delaware Bay (Auster 1989). Tautog are known to move in and out of bays or inshore and offshore according to the water temperature, but they do not make extensive migrations up and down the coast. Preferred environs include shallow waters over rocky bottoms, shell beds, and inshore wrecks which they often inhabit year-round. The diet of tautog is mainly mollusks and crustaceans, with blue mussels being especially favored where abundant. The tautog uses the flat, rounded, stout teeth located in the rear of its mouth to crush the shells of mollusks or crustaceans. Predators of tautog include striped bass, bluefish, sharks and skates (Auster 1989).

Habitat Characteristics by Lifestage

Adult tautog inhabit rocky areas and areas around pilings, seawalls and wharves. The adults are aggressive feeders and usually occur in schools or small groups. Spawning occurs from late April to early August in bays and offshore. Eggs are buoyant and are present in the water column in June. Tautog eggs lack an oil globule and range in size from 0.9 to 1 mm. Larvae are 2.2 mm and the yolk sac is absorbed at 3.3 mm. The young are planktonic for about three weeks and then take up residence in the camouflaged safety of green seagrass beds. The young fish lose their bright green coloring as they mature–usually in three to four years–and become uniformly black (Auster 1989). A mature young tautog is approximately 33 cm long, and maximum adult size is 1.0 m. A slow-growing fish, the tautog can live for more than 30 years. In older fish, the sex ratio is known to be skewed toward males, larger fish with an enlarged white chin. Older females resemble young fish, retaining their uniform black coloring (Auster 1989).

Distribution & Occurrence in Long Island Sound

Tautog abundance was low for all years of the CTDEP trawl survey (ENSR 2001). Average catch for this species declined since the first year of the survey and remained at consistently low numbers for the past 15 years. Average abundance for tautog was higher in the spring although, in recent years, this seasonal difference is minimal. Tautog captured in this survey ranged from 8 to 66 cm with little variation in monthly size composition (Gottschall *et al.* 2000). The majority of fish were adults, ranging from 86% of the catch in April to 97.5% of the catch in August. Tautog individuals were commonly observed in most months of the survey, ranging from 15.4% occurrence in September to 50.2% in May. Tautog abundance in the survey was highest from May through July, dropped in August and then increased slightly in October and November.

From May through October tautog were most abundant in depths less than 18 m over all bottom types. During those months, tautog concentrations occurred in certain areas, several locations between New Haven and Norwalk, CT, north of Hempstead, NY and off Eaton's Neck, CT and Mattituck, NY. All of these areas were typically less than 18 m deep and are adjacent to rocky structure. In contrast with May

through October, tautog were more dispersed in November. They were found in all depths, although primarily in depths greater than 9 m and were most abundant over mud bottoms.

3.23 WEAKFISH (*CYNOSCION REGALIS*)

Designated Lifestages

There is no essential fish habitat designated for weakfish, however, adults of this species can be found in both Block Island Sound and Long Island Sound.

Biology & Distribution

The following summary is based on the information presented in Gottschall *et al.* (2000), http://www.fishbase.org and the Angler's Encyclopedia http://www.kenschultz.com/.

Weakfish are slim and shaped somewhat like a trout. The lower jaw projects beyond the upper jaw. There are two large, protruding canine teeth in the upper jaw, and no chin barbells. Its coloring is dark olive or greenish to greenish blue on the dorsal surface, and blue, green, purple, and lavender with a golden tinge on the sides (Mercer 1989). Numerous small black spots speckle the top, sometimes forming wavy diagonal lines. There is sometimes a black margin on the tip of the tongue. Weakfish inhabit the western Atlantic Ocean from Florida to Massachusetts, and records show isolated populations occurring as far north as Nova Scotia. It is most abundant from North Carolina to Florida in the winter and from Delaware to New York in the summer (Mercer 1989).

Mature female weakfish (ages 1 and older) produce large quantities of eggs that are fertilized by mature males (ages 1 and older) as they are released into waters of nearshore and estuarine spawning areas. Length at maturity is less for southern fish than for northern fish. Southern fish are suggested to produce more eggs at smaller size than do northern fish (Mercer 1989). Recent work on weakfish fecundity indicated that weakfish are batch rather than total spawners. In other words, females release their eggs over a period of time, rather than all at once. Spawning occurs in nearshore and estuarine areas from March through September, with a peak from April to June.

The fertilized eggs hatch into larvae in 36 - 40 hours at temperatures of 20 -21°C. The larvae and post-larvae begin feeding on macroscopic animals during their journey from spawning areas to coastal nursery areas and continue to feed on these small animals after their arrival in the nursery areas, located in the deeper portions of coastal rivers, bays, sounds, and estuaries and grow into juveniles (Mercer 1989). Juveniles remain in coastal sounds and estuaries until October through December of their first year, after which they migrate to the Atlantic Ocean. Weakfish in the northern end of the range leave the inshore areas earlier than the weakfish in the southern end of the range.

Habitats used by weakfish include: spawning sites in coastal bays, sounds and their nearshore Atlantic ocean and nursery areas that include the lower portions of the rivers and their associated bays and estuaries. These types of habitats are distributed along the coasts from Maine through Florida. Weakfish feed primarily on penaeid and mysid shrimps, anchovies, and clupeid fishes (menhaden, river herring, shad). Juvenile weakfish feed mostly on mysid shrimp and anchovies. Older fish feed on clupeids or anchovies and other fishes, including butterfish, herrings, juvenile weakfish, Atlantic croaker, spot, scup, and killifishes. Invertebrates in the diet in addition to shrimp include squids, crabs, annelid worms and clams. Weakfish are important top carnivores where they consume. Predators of weakfish include lampreys, sharks, skates, bluefish, and striped bass (Mercer 1989).

Habitat Characteristics by Lifestage

Weakfish usually occur in shallow coastal waters over sand and sandy mud bottoms. During summer the fish move to their nursery and feeding grounds in river estuaries. In the estuary, adult weakfish occur in schools and frequent shallow sandy bottom areas with salinities above 10 percent. Estuaries provide feeding areas and spawning grounds for adult weakfish and are as important as nursery areas are for juveniles.

Distribution & Occurrence in Long Island Sound

Weakfish were moderately to highly abundant in the CTDEP trawl survey (ENSR 2001). Weakfish mainly occur in Long Island Sound in the fall. Few spring captures have been recorded since the survey began. The highest mean catch of weakfish occurred in 2000 when more than 460 fish were collected per tow. Weakfish taken in the survey ranged from 3 to 90 cm (Gottschall *et al.* 2000). Most weakfish taken from May through July were adults, although one 5 cm weakfish was observed in June. Young-of-the-year generally first appeared in survey catches in August and comprised about 98% of the catch through October. After first appearing in survey catches in May, weakfish abundance increased slightly thereafter through late spring and summer. Abundance increased dramatically through the fall period as young-of-the-year recruited to the survey trawl and then dropped in November.

Most adults were taken, in the spring, along the Mattituck Sill and along both coastlines into the Western Basin of Long Island Sound. They occurred in all of the survey strata but abundance tended to be highest over transitional bottom in depths less than 18 m. During the summer and fall, weakfish were still distributed throughout the same areas as spring. In addition, during the fall period adult weakfish appeared to be more abundant along the Long Island side of the Central Basin, whereas in spring and summer more were distributed along the Connecticut side.

Young-of-the-year were more widely distributed than adults. They were most abundant in the Central and Western Basins over mud bottoms with most of the largest catches occurring along the Long Island side of the Sound.

3.24 WINDOWPANE FLOUNDER (*SCOPHTHALMUS AQUOSUS*)

Designated Lifestages

All of Long Island Sound and the Peconic Estuary are designated essential fish habitat for eggs, larvae, juveniles and adults of the windowpane flounder species. Block Island Sound is essential fish habitat for juvenile and adult windowpane flounder, only.

Biology & Distribution

The following summary of windowpane flounder biology and distribution is adapted from the NOAA technical source document (NMFS-NE-137, 1999) and Gottschall *et al.* (2000). The windowpane flounder is a left-eyed flounder with a thin body and nearly round outline. Adult windowpane flounder are found from the Gulf of Saint Lawrence to Florida (Scott and Scott, 1988) but are most abundant from Georges Bank to Chesapeake Bay. Windowpane flounder generally inhabit shallow waters with sand to sand/silt or mud substrates. They are most abundant from depths of 1-2 m to depths of <56 m. They occur in the bays and estuaries south of Cape Cod, including Long Island Sound and Block Island Sound.

In Long Island Sound, adult windowpane flounder have their greatest abundance from April through June. Windowpane flounder attain a maximum total length of about 46 cm (Scott and Scott, 1988). Few age and growth studies of windowpane flounder have been conducted. It is a fast growing species with spring and summer being the period of greatest growth (Moore, 1947).

Juvenile windowpane flounder have oval bodies that are wider than in other left-eyed flounders. The body and fins are heavily pigmented in larger young-of-the-year, smaller individuals are characterized by broad alternating dark and light bands. The growth patterns of juveniles in estuaries and on the shelf vary with the timing of spawning. Fish spawned in the spring grow quickly and reach sizes of 11-19 cm total length by September, about four months after spawning. By the following spring, most fish of this cohort are larger than 16-cm total length. Fish spawned in the autumn are 4-7 cm total length in December and reach 18-21 cm total length by the following October (Morse and Able, 1995).

At hatching, windowpane larvae are approximately 2mm long (Able and Fahay, 1998). As development proceeds, the body becomes deeper and more laterally compressed. Fin ray formation is complete at about 11.5-mm total length.

Spawning occurs throughout most of the year. Spawning begins in February or March in the Inner Shelf waters, peaks in the Middle Atlantic Bight in May, and extends onto Georges Bank during the summer (Able and Fahay, 1998). Evidence for a split spawning season is available for Long Island Sound waters (Wheatland 1956) and for Great South Bay, New York (Dugay *et al.* 1989). Gonad development indicated that split spawning off New Jersey and New York peaks in May and in September (Wilk *et al.* 1990). However, neither Perlmutter (1939) nor Smith *et al.* (1975) found evidence for a split-spawning season in Long Island Sound.

Habitat Characteristics by Lifestage

Windowpane flounder spawn in the evening or at night on or near bottom at temperatures ranging from 6-21°C (Bigelow and Schroeder 1953). Sexual maturity occurs at 3-4 years of age when about 50% of females that are 22-cm total length are sexually mature. Females grow larger and faster than males after sexual maturity (O'Brien *et al.* 1993). The eggs of windowpane flounder are pelagic and spherical with a diameter of 0.9-1.4 mm and a single oil globule 0.2-0.3 mm in diameter (Wheatland 1956).

Juveniles that settle in shallow inshore waters move to deeper offshore waters as they grow and both juvenile and adults may migrate to nearshore or estuarine habitats in the Southern Middle Atlantic Bight in the autumn. However, juveniles are probably not adequately sampled by standard Northeast Fisheries Science Center trawl gear (Morse and Able, 1995).

Distribution & Occurrence in Long Island Sound

The spring abundance of windowpane flounder abundance has decreased considerably since the trawl survey began in 1984 (ENSR 2001). In the spring of 1984 an average of 314 fish were collected per tow, while in the spring of 2000 only 23 fish were captured per tow. The fall abundance of windowpane flounder has remained consistent but low over the course of the survey.

Adult windowpane flounder were found distributed within the Long Island Sound throughout the year. In both the Long Island Sound and Block Island Sound windowpane flounder were found over mud substrate. Windowpane flounder were broadly distributed in most regions of Long Island Sound. Regions of highest mean abundance were deep habitats within the Central and Western Basins containing mud and transitional sediment. Relatively few adult windowpane flounder were collected in the eastern end of the Sound.

The majority of windowpane flounder collected in April and May were adults while juveniles (young-of-the-year and 1+) dominated windowpane flounder catches in the summer and fall (Gottschall *et al.* 2000). Juvenile windowpane flounder can also be found on Georges Bank and other offshore shallow areas during fall and winter.

3.25 WINTER FLOUNDER (*PSEUDOPLEURONECTES AMERICANUS*)

Designated Lifestages

All of Long Island Sound, Block Island Sound and the Peconic Estuary are designated essential fish habitat for egg, larval, juvenile, and adult life stages of winter flounder.

Biology & Distribution

The following summary of winter flounder biology and distribution is adapted from the NOAA technical source document (Pereira *et al.* 1999) and Gottschall *et al.* (2000). The winter flounder is a small-mouthed, right-eyed flounder and is a valuable commercial and recreational species. It is distributed along the northwest Atlantic coast as far north as Labrador (Kendall 1909) and as far south as North Carolina and Georgia (Hildebrand and Schroeder 1928; Buckley 1989; Grimes *et al.* 1989). The species is managed as three separate stocks: the Gulf of Maine, southern New England and the Middle Atlantic, and Georges Bank (Brown and Gabriel 1998) and the life history of winter flounder has been well-studied (Howell et al 1992).

The eggs of winter flounder are demersal and adhesive. They stick together in clusters. The eggs range in size from 0.74-0.85 mm in diameter. Hatching occurs in 2 to 3 weeks, depending on temperature, and at sizes as small as 2.4 mm in the Northwest Atlantic (Fahay 1983) and up to 3.0-3.5 mm in the Gulf of Maine (Bigelow and Schroeder 1953; Buckley 1989; Grimes *et al.* 1989).

Larvae are initially planktonic but become bottom oriented as metamorphosis approaches. Settlement occurs at 9-13 mm standard length (SL) (Peacy 1962; Grimes *et al. 1989;* Witting 1995). Metamorphosis, when the left eye migrates to the right side of the body and the larvae become “flounder-like” begins around 5 to 6 weeks after hatching. Metamorphosis is completed by the time the larvae are 8-9 mm in length at about 8 weeks after hatching (Bigelow and Schroeder 1953). Variation in age at metamorphosis is greater than for size with age variation influenced by temperature (Laurence 1975).

A large percentage of the stomach contents - nauplii, harpacticoids, calanoids, polychaetes, invertebrate eggs and phytoplankton - were present in the guts of flounder larvae through metamorphosis (Pearcy 1962; Grimes *et al.* 1989).

Calanoids and harpacticoids were important foods for metamorphosing and recently metamorphosed with flounder. Amphipods and polychaetes gradually become more important for both young-of-the-year and yearling flounder (Pearcy 1962). Winter flounder are omnivorous feeders, consuming a variety of prey. Polychaetes and crustaceans generally make up the bulk of the adult winter flounder diet. Annelids, amphipods dominate the diet in almost all size classes. Winter flounder spend their first year in very shallow inshore waters. Although temperature tolerance of young-of-the-year is higher than for yearlings

and adults, Pearcy (1962) concluded that temperatures of 30°C might be too high. Young-of-the-year flounder also tolerate lower salinities than do yearling flounder and can tolerate lower levels of dissolved oxygen.

Adult winter flounder are sight feeders, using their dorsal fins to raise their heads off the bottom with eye turrets extended for a better view (Olla et al, 1969). Degradation or improvement of environmental conditions causing shifts in benthic invertebrate populations may also cause shifts in pre-selection such as eating the pollution-tolerant polychaete *Capitella* or eating the pollution sensitive amphipod *Unciola irrorata* once environmental conditions have improved (Grimes *et al.* 1989; Steimle et al 1993).

Adult winter flounder are preyed upon by a variety of predators including striped bass, bluefish, spiny dogfish, goosefish, oyster toadfish, and sea raven. Cormorants, blue herons, seals, and ospreys have also been cited as predators (Pearcy 1962). Juveniles and young-of-the-year are preyed upon by small medusa, predatory amphipods, anemones, and Atlantic mackerel. Gulls, cormorants and bluefish, along with shrimp, sea robins, and windowpane flounder have also been documented to prey on winter flounder juveniles (Buckley 1989).

Habitat Characteristics by Lifestage

Winter flounder spawn from winter through spring with peak spawning occurring during February and March in Massachusetts Bay and south of Cape Cod in shallow coastal embayments. Spawning occurs earlier in the southern part of the range. Major egg production occurs in New England waters before temperatures reach 3.3°C with an upper limit of about 4.4-5.6°C (Bigelow and Schroeder, 1953; Buckley, 1989). Fecundity measurements indicate that in Rhode Island 25-450 mm females produced from 93,000 to over 1.3 million eggs (Kennedy and Steele, 1971; Grimes *et al.* 1989). Spawning was concentrated between sunset and midnight with the majority of spawning events involving more than one male, which potentially maximizes fertilization success.

The utilization of shallow bays and estuaries by winter flounder for spawning and nursery areas has been well documented. Less well studied is the utilization of nearby coastal waters the stock and how anthropogenic conditions, which decrease spawning habitat, effect juvenile habitat and the food web.

Commercial fisheries for winter flounder flourished prior to 1980, even in the southern end of the range. In the southern New England-Middle Atlantic stock, stock biomass declined from 39,000 mt in 1981 to a record low of 8,500 mt in 1992 (Brown and Gabriel 1998). Contributions from strong year classes in 1992 and 1994 have rebuilt the stock biomass to 18,000 mt in 1996 but the stock remains overexploited (Brown and Gabriel 1998).

Distribution & Occurrence in Long Island Sound

Winter flounder were highly abundant in the CTDEP trawl survey from 1984 to 1991; in most of these years, average catches were greater than 100 fish per tow (ENSR 2001). Since 1992 the relative abundance of winter flounder has dropped. In 2000, the year with the lowest mean catch for winter flounder, sampling averaged 46 fish per tow. Winter flounder were significantly more abundant in spring versus fall samples.

Although winter flounder were broadly distributed in Long Island Sound during both spring and fall, there was a seasonal difference in their relative abundance in deep versus shallow habitats. In the spring the highest catches of winter flounder occurred in mud and transitional habitats in the Central Basin. In the fall, winter flounder were comparatively more abundant in shallower habitats in both the Central and Western Basins. In both seasons, mean abundance of winter flounder decreased west to east across the Sound (ENSR 2001).

Adult winter flounder can be found from the Gulf of Saint Lawrence to the Chesapeake but have their greatest abundance from Georges Bank to Chesapeake Bay. Winter flounder generally inhabit shallow waters with mud substrates. They can occur in the bays and estuaries south of Cape Cod, including Long Island Sound and Block Island Sound.

Adult winter flounder in the Long Island Sound and Block Island Sound areas migrate inshore in the fall and early winter and spawn in late winter and early spring. Following spawning, adults typically leave inshore areas when water temperatures exceed 15°C (McCracken 1963). This species is currently managed as three stocks which were first distinguished based on differences in fin ray counts and movement patterns.

Spawning, for various populations of this species, occur throughout most of the year (Buckley 1989). Spawning begins in February or March in the Inner Shelf waters, peaks in the Middle Atlantic Bight in May, and extends onto Georges Bank during the summer (Buckley 1989; Able and Fahay, 1998). Evidence for a split-spawning season is available for Long Island Sound waters (Wheatland 1956) and for Great South Bay, New York. Gonad development indicated that split spawning off New Jersey and New York peaks in May and in September (Wilk *et al.* 1990). However, neither Perlmutter (1939) nor Smith *et al.* (1975) found evidence for a split-spawning season in Long Island Sound.

3.26 AMERICAN LOBSTER (*HOMARUS AMERICANUS*)

Designated Lifestages

Long Island Sound, particularly the western end, and Block Island Sound are considered part of the essential fish habitat that is designated for egg, larval, juvenile, and adult life stages of the American lobster.

Biology & Distribution

The following summary of American lobster biology and distribution is adapted from the Gottschall *et al.* (2000) and NOAA Technical Memorandum NMFS-NE-115. The American lobster is distributed in the Northwest Atlantic from Labrador to Cape Hatteras, from coastal regions out to depths of 700 m. Lobsters are locally abundant in coastal regions within the Gulf of Maine and off southern New England.

Small lobsters undertake limited movement, although larger individuals may travel extensively (MacKenzie and Moring 1985; MacKenzie *et al.* 1985). In contrast, offshore lobsters show well-defined shoalward migrations during the spring, traveling as much as 300 km. Three stock areas - the Gulf of Maine, Georges Bank and South, and South of Cape Cod to Long Island Sound - have been recognized for assessment purposes.

Lobsters exhibit a complex life cycle in which mating occurs following molting of the female. Eggs (7,000 to 80,000) are extruded and carried under the female's abdomen during a 9 to 11 month incubation period. The eggs hatch during late spring or early summer and the pelagic larvae undergo four molts before attaining adult characteristics and settling to the bottom. Lobsters molt approximately 20 times before reaching minimum legal size. Significant portions of the female lobsters caught in shore areas are not sexually mature (MacKenzie and Moring 1985; MacKenzie *et al.* 1985).

Larval lobsters probably sustain themselves during this phase by feeding on plankton drifting by; juveniles most likely consume benthic organisms found in the immediate vicinity of their shelters. Adult lobsters are opportunistic species feeding on a variety of organisms including fish, polychaetes, mollusks, and other crustaceans. Adult lobsters will scavenge for food, consume carrion and be cannibalistic. Codfish, dogfish, skate and catfish are known predators of the American lobster (MacKenzie and Moring 1985; MacKenzie *et al.* 1985).

Habitat Characteristics by Lifestage

Lobsters select specific nursery grounds for settlement and studies have shown that their survivorship is greater in nursery grounds having specific architectural characteristics (MacKenzie and Morning 1985; MacKenzie *et al.* 1985; Hudon and Lamarche, 1989). All known nursery grounds for lobsters contain

small shelter providing spaces. In many regions throughout coastal New England, cobblestones contain the greatest densities of newly settled lobsters (Wahle and Steneck 1991). Newly settled lobsters remain near their settlement site for the first several years. Recent studies have shown that lobster settlement is largely limited to water shallower than 20 m. Cobbles and boulders provide a protective habitat for juvenile lobsters.

Adult coastal lobsters are concentrated in rock areas where shelter is readily available although occasional high densities occur in mud substrates suitable for burrowing. Offshore populations are most abundant near submarine canyons along the Continental Shelf edge.

Distribution & Occurrence in Long Island Sound

American lobsters were highly abundant in CTDEP trawls, particularly in the fall (ENSR 2001). The average catch for lobsters in the trawl survey increased slightly during the 1990s. An unusually high number of lobsters were collected in the fall of 1997 (mean of 139 lobsters/tow) while the lowest catches occurred in the spring of 1986 (mean of 9 lobsters/tow). Lobsters taken in the survey ranged from 18 to 126 mm carapace length, with the distribution of lengths similar in all seasons (Gottschall *et al.* 2000). The percentage of juvenile lobsters ranged from 16.4% in November to 23.9% in October.

Although lobsters were found throughout Long Island Sound during all seasons - percentage occurrence ranged from 67.0% in April to 79.0% in July - abundance was highest on mud bottom. Further, there were three areas with mud bottom in particular where lobsters were concentrated: the Western Basin, which contained the largest concentration of lobsters; the area between the Housatonic River and south of New Haven Harbor; and north of Shoreham, New York. In the Western Basin, abundance was generally highest in depths from 9 to 18 m. The area between the Housatonic River and New Haven is comprised of mud and transitional bottom, with depths generally less than 18m. The third area north of Shoreham is primarily mud bottom, with depths greater than 18 m. In addition to these three areas, lobsters were abundant on transitional bottom in Niantic Bay and the mouth of the Thames River during the spring and fall sampling periods.

3.27 LONG-FINNED INSHORE SQUID (*LOLIGO PEALEII*)

Designated Lifestages

Essential fish habitat is designated for egg, larval, juvenile, and adult life stages of long-finned inshore squid throughout Long Island Sound and Block Island Sound.

Biology & Distribution

The long-finned inshore squid, *Loligo pealeii*, is a pelagic schooling species of mollusk. It is distributed in Continental Sshelf and slope waters from Newfoundland to the Gulf of Venezuela. The population is managed as a single stock unit.

The following summary of long-finned inshore squid biology is adapted from Cargnelli *et al.* (1999) and Gottschall *et al.* (2000). Eggs of long-finned inshore squid are encased in a gelatinous capsule as they pass through the female oviduct during mating. Each capsule contains 150-200 eggs and is 1mm x 1.6 mm in size. The entire capsule is 50-80 mm long and 1 cm in diameter. During spawning, the male cements bundles of spermatophores into the mantle cavity of the female. The egg capsules are laid on the seafloor in clusters of 50-60 cm wide composed of hundreds of capsules (Gosner 1978). The number of eggs spawned per female has been reported as 950-8,500 (Haefner 1959).

Little is known about the larval stages of the long-finned inshore squid (MAFMC 1996) because they are not often found in the spawning areas. Larvae are pelagic in near surface waters (McMahon and Summers 1971). There are two juvenile stages; juvenile is the stage after the paralarval stage and before maturity when the morphological characteristics of adults are attained (Young and Harman 1988). The shift from inhabiting surface waters to a subadult lifestyle occurs at 45 mm (Vecchione 1981). Subadults can overwinter in deeper waters along the edge of the Continental Shelf and young-of-the-year are found with adults in mid-summer trawls (Cargnelli 1999).

Adults have been show to live up to 1 year (Brodziak and Macy 1996). The long-finned inshore squid reach sizes greater than 40-50 cm mantle length (ML), although most are less than 30 cm. They are sexually dimorphic; males grow more rapidly and reach larger size at age than females (Brodziak 1995). Long-finned inshore squid migrate offshore during late autumn and overwinter in warmer waters along the Continental Shelf. They return inshore during the spring and early summer. Long-finned inshore squid form schools and make diurnal vertical migrations up into the water column at night (MAFMC 1996). This movement may be associated with the movement of prey.

Brodziak and Macy (1996) recently reported that long-finned inshore squid could spawn year round. Most eggs are spawned in May and hatching occurs in July. Most spawning in the Middle Atlantic occurs from late spring to early summer (Black *et al.* 1987).

The diet of the long-finned inshore squid changes with size. Small immature individual feed on planktonic organisms while larger individuals feed on crustaceans and small fish. Cannibalism is observed. Juveniles feed on euphausiids, arrow worms, small crabs, polychaetes, and shrimp. Adults feed on fish and squid larvae/juveniles, and smaller adult squid. Juvenile and adult long-finned inshore squid are preyed upon by many pelagic and demersal fish species as well as marine mammals and diving birds

(Vovk and Khvichiya 1980). Marine mammal predators include long-finned pilot whale and common dolphin. Fish predators include bluefish, sea bass, mackerel, cod, haddock, pollock, silver and red hake, sea raven, spiny dogfish, and flounder (Maurer 1975, Gosner 1978).

Habitat Characteristics by Lifestage

Egg masses are commonly found attached to rocks and small boulders on sandy/muddy bottom and on aquatic vegetation (Arnold *et al.* 1974). The larvae are pelagic near the surface and occur at temperatures of 10-26°C. Surface waters are important to hatchlings and larvae move deeper as they grow older (Vecchione 1981).

Juveniles inhabit the upper 10 m of the water column over water 50-150 m deep. They are found at surface water temperatures 10-26°C (Vecchione 1981). In Narragansett Bay, pre-recruits were found at depths of 3-34 m over all seasons. In the Hudson-Raritan estuary, most pre-recruits were found at temperatures of 16-20°C, depths of 9 and 14-15 m.

Adult long-finned inshore squid inhabit the Continental Shelf and Upper Continental slope to depths of 400 m (Vecchione *et al.* 1989) but depths vary seasonally. In spring, they occur at depth of 110-200m, in summer and autumn they inhabit inshore waters as shallow as 6-28 m and in winter, they inhabit offshore waters to depths of 365 m. They are found on mud or sand/mud substrate at surface temperatures ranging from 9-21°C and bottom temperatures ranging from 8-16°C. In Narragansett Bay, recruits were found at depths of 3-37 m. In the Hudson-Raritan estuary, most recruits were found at temperatures of 16-17°C, depths of 15-18 m.

Distribution & Occurrence in Long Island Sound

Long-finned squid were among the most abundant species collected during fall CTDEP trawl sampling (ENSR 2001). Squid were relatively less abundant in the spring (mean of less than 100 squid per tow), although their numbers during this season remained almost constant throughout the study period. In the fall of 1993, mean squid abundance peaked at 500 individuals per tow. In most years, the abundance of squid in the fall averaged approximately 200 individuals per tow. The highest catches were dominated by small squid ranging from about 2-12 cm (Gottschall *et al.* 2000).

Long-finned squid were broadly distributed in the Sound during the fall. Squid were most abundant in mud and transitional habitats at depths greater than 18 meters. In spring, before squid became abundant in the Long Island Sound, most individuals were collected in the Eastern Basin (ENSR 2001).

Long-finned inshore squid recruits (>8 cm ML) were captured in the Hudson-Raritan estuary during spring, summer and fall. They were found mostly in the eastern portion of the bay. The highest catches

occurred in summer and autumn. Long-finned inshore squid require oxygen concentrations greater than 4 mg/L (Howell and Simpson 1994).

4.0 REFERENCES

Able, K.W., R.E. Matheson, W.W. Morse, M.P. Fahay, and G. Shepherd. 1990. Patterns of summer flounder *Paralichthys dentatus* early life history in the Mid-Atlantic Bight and New Jersey estuaries. Fisheries Bulletin (U.S.) 88:1-12.

Able, K.W. and M.P. Fahay. 1998. The First Year in the Life of Estuarine Fishes in the Middle Atlantic Bight. Rutgers University Press, New Brunswick, New Jersey.

Able, K.W., M.P. Fahay, and G.R. Shepherd. 1995a. Early life history of black sea bass, *Centropristis striata*, in the Mid-Atlantic bight and New Jersey estuary. Fisheries Bulletin (U.S.) 93: 429-445.

Able, K.W., A.L. Studholme, and J.P. Manderson. 1995b. Habitat quality in the New York/New Jersey Harbor estuary: An evaluation of pier effects on fishes. Final report to the Hudson River Foundation. Rutgers University Marine Field Station, Institute of Marine and Coastal Sciences, Tuckerton, NJ and NOAA/NMFS/NEFSC, James J. Howard Marine Sciences Laboratory, Highlands, NJ. 85pp.

Alexander, M.S. 1981. Population response of the sequential hermaphordite black sea bass, Centropristis striata, to fishing. M.S. thesis, State University of New York, Stony Brook. 104 pp.

Anderson, E.D. 1982. Status of the northwest Atlantic mackerel stock-1981. U.S. National Marine Fisheries Service Northeast Fisheries Center. Woods Hole Lab Reference Document 81-38: 38 pp.

Anthony, V.C. 1972. Population dynamics of the Atlantic herring in the Gulf of Maine. Ph.D. dissertation, University of Washington, Seattle, WA 266 pp.

Arnold, J.M., W.C. Summers, D.L. Gilbert, R.S. Manalis, N.W. Daw, and R.J. Lasek. 1974. A guide to laboratory use of the squid, *Loligo pealei*. Marine Biological Laboratory, Woods Hole, MA. 74 pp.

Auster, P.J. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (north Atlantic and mid-Atlantic)—tautog and cunner. U.S. Fish and Wildlife Service Biological Report. 82(11.105). U.S. Army Corps of Engineers. TR EL-82-4. 13 pp.

Bejda, A.J., A.L. Studholme, and B.L. Olla. 1987. Behavioural responses of red hake, Urophycis chuss, to decreasing concentrations of dissolved oxygen. Environmental and Biological Fishes 19: 261-268.

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. U.S. Fish and Wildlife Service. Fisheries Bulletin. 53, 577 pp.

Black, G.A.P., T.W. Rowell, and E.G. Dawe. 1987. Atlas of the biology and distribution of the squids *Illex illecebrosus* and *Loligo pealei* in the northwest Atlantic. Canadian Special Publications of Fisheries and Aquatic Sciences. 100. 62 pp.

Blaxster, J.H.S. 1985. The herring: a successful species? Canadian Journal of Fisheries and Aquatic Sciences. 42: 21-30.

Bowen, B.W. and J.C. Avise. 1990. Genetic structure of Atlantic and Gulf of Mexico populations of sea bass, menhaden, and sturgeon: influence of zoogeographic factors and life-history patterns. Marine Biology. 107: 371-381.

Bowman, R.E., R.O. Maurer, Jr. and J.A. Murphy. 1976. Stomach contents of twenty-nine fish species from five regions in the northwest Atlantic-Data report. U.S. National Marine Fisheries Service Northeast Fisheries Center. Woods Hole Laboratory Reference Document Number 76-10. 37 pp.

Brodziak, J.K.T. 1995. Long-finned squid. In Conservation and Utilization Division, Northeast Fisheries Science Center eds. Status of the fishery resources off the Northeastern United States for 1994. P. 112-113. NOAA Technical Memorandum. NMFS-NE-108.

Brodziak, J.K.T. and W.K. Macy, III. 1996. Growth of long-finned squid, *Loligo pealei*, in the northwest Atlantic. Fisheries Bulletin (U.S.) 97: 212-236.

Brown, R. and W. Gabriel. 1998. Winter flounder. In Clark, S.H. ed. Status of the fishery resources off the northeastern United States for 1998. P. 81-84. NOAA Technical Memorandum NMFS-NE-15.

Buckley, J. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)—winter flounder. U.S. Fish and Wildlife Service Biological Report 82(11.87). U.S. Army Corps of Engineers, TR-EL-82-4. 12 pp.

Cargnelli, L.M., S.J. Griesbach, D.B. Packer, P.L. Berrien, D.L. Johnson, and W.W. Morse. 1998. Essential Fish Habitat Source Document: Pollock, *Pollachius virens*, life history and Habitat characteristics. NOAA Technical Memorandum NMFS-NE-131. 35 pp.

Cargnelli, L.M., S.J. Griesbach, C. McBride, C.A. Zetlin, and W.W. Morse. 1999. Essential Fish Habitat Source Document: Longfin inshore squid, *Loligo pealeii*, life history and habitat characteristics. NOAA Technical Memorandum NMFS-NE-146. 32 pp.

Chiarella, L.A. and D.O. Conover. 1990. Spawning season and first-year growth of adult bluefish from the New York Bight. Transactions of the American Fisheries Society. 119(3): 455-462.

Clark, S.H. 1998. Status of fishery resources off the northeastern United States for 1998. NOAA Technical Memorandum NMFS-NE-115. 147 pp.

Collette, B. B and C. E. Nauen. 1983. FAO species catalogue Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. FAO Fish. Synop., (125) Vol. 2: 137 p.

Creasar, E.P. and H.C. Perkins. 1994. The distribution, food, and age of juvenile bluefish, *Pomatomus saltatrix*, in Marine Fisheries Bulletin (U.S.) 92(3): 494-508.

Cross, J.N., C.A. Zetlin, P.L. Berrien, D.L. Johnson, and C. McBride. 1999. Essential Fish Habitat Source Document: Butterfish, *Peprilus triacanthus*, life history and habitat characteristics. NOAA Technical Memorandum NMFS-NE-145. 38 pp.

Dery, L.M. 1988. Butterfish, *Peprilus triacanthus*. In J. Pentilla and L.M. Dery eds. Age determination methods for northwest Atlantic species. Pp. 85-92. NOAA Technical Report NMFS-72.

Deuel, D.G., J.R. Clark, and A.J. Mansuetti. 1966. Description of embryonic and early larval stages of bluefish, *Pomatomus saltatrix*. Transactions of the American Fisheries Society 95(3): 264-271.

ENSR. 2001. Analysis of Connecticut Department of Environmental Protection Trawl Data for Long Island Sound. Document No. Long Island Sound-2001-A09-FC1. Final, November, 2001.

Fahay, M.P. 1983. Guide to the early stages of marine fishes occurring in the western North Atlantic Ocean, Cape Hatteras to the southern Scotian Shelf. Journal of the Northwest Atlantic Fisheries Society. 4: 1-423.

Fahay, M.P., P.L. Berrien, D.L. Johnson, and W.W. Morse. 1999. Essential Fish Habitat Source Document: Bluefish, *Pomatomus saltatrix*, life history and habitat characteristics. NOAA Technical Memorandum, NMFS-NE-144. 70 pp.

Fay, C.W., R.J. Neves, and G.B. Pardue. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic)—striped bass. U.S. Fish and Wildlife Service, Division of Biological Services, FWS/OBS-82/11.8. U.S. Army Corps of Engineers. TR EL-82-4. 36 pp.

Fritzsche, R.A. 1978. Development of fishes of the Mid-Atlantic Bight. An atlas of egg, larval, and juvenile stages. Volume 5. Chaetodontidae through Ophidiidae. U.S. Fisheries and Wildlife Service Biological Services Program. FWS/OBS-78/12. 340 pp.

Garman, G.C. 1983. Observations on juvenile red hake associated with sea scallops in Frenchman Bay, Maine Transactions of the American Fisheries Society. 112: 212-215.

Gilbert, C.R. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Mid-Atlantic Bight)—Atlantic and shortnose sturgeons. U.S. Fish and Wildlife Service Biological Report 82(11.122). U.S. Army Corps of Engineers TR EL-82-4. 28 pp.

Gosner, K.L. 1978. A field guide to the Atlantic seashore: Invertebrates and seaweeds of the Atlantic coast from the Bay of Fundy to Cape Hatteras. Houghton Miflin Company, Boston, MA. 329 pp.

Gottschall, K.F., M.W. Johnson, and D.G. Simpson. 2000. The Distribution and Size Composition of Finfish, American Lobster, and Long-finned Squid in Long Island Sound based on the Connecticut Fisheries Division Bottom Trawl Survey, 1984-1994. U.S. Dept. of Commerce, NOAA Technical Report NMFS 148.

Grimes, B.H., M.T. Huish, J.H. Kerby, and D. Moran. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic)—summer and winter flounder. U.S. Fish and Wildlife Service Biological Report. 82(11.112). U.S. Army Corps of Engineers, TR EL-82-4. 18 pp.

Haefner, P.A., Jr. 1959. Morphometry and biology of *Loligo pealei* (LeSuer, 1821) and *Lolliguncula brevis* (Blainville, 1823) in Delaware Bay. M.S. thesis. University of Delaware. Newark, DE. 61 pp.

Hardy, J.D. Jr., 1978. Development of fishes of the Mid-Atlantic Bight: An atlas of egg, larval and juvenile stages. Volume 2 Anguillidae through Syngnathidae. U.S. Fish and Wildlife Service Biological Services Program. FWS/OBS-78/12. 458 pp.

Hare, J.A. and R.K. Cowen. 1994. Ontogeny and otolith microstructure of bluefish *Pomatomus saltatrix* (Pisces: Pomatomidae). Marine Biology. 118: 541-550.

Hildebrand, S.F. and W.C. Schroeder. 1928. Fishes of Chesapeake Bay. Bulletin of the U.S. Fur. Fisheries. 43(1): 366 pp.

Howell, P., A. Howe, M. Gibson, and S. Ayvazian. 1992. Fishery management plan for inshore stocks of winter flounder, *Pleuronectes americanus*. Fisheries Management Report of the Atlantic States Fisheries Commission, No. 21. 138 pp.

Howell, P. and D. Simpson. 1994. Abundance of marine resources in relation to dissolved oxygen in Long Island Sound. Estuaries. 17: 394-402.

Hudon, C., Lamarche, G. 1989. Niche segregation between American lobster, *Homarus americanus* and rock crab Cancer irroratus. Mar. Ecol. Prog. Ser. 52: 155 - 168.

Kelly, K.H. and J.R. Moring. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)—Atlantic herring. U.S. Fish and Wildlife Service Biological Report. 82(11.38). U.S. Army Corps of Engineers. TR EL-82

Kendall, W. 1909. The fishes of Labrador. Proceedings of Portland Society of Natural History. 2:207-243.

Kendall, W. C. 1939. Founders of fish culture: Charles Grandison Atkins - a pioneer who blazed the trail. Progressive Fish Culturist (No. 25): 12-17.

Kenedy, V.S. and D.H. Steele. 1971. The winter flounder, *Pseudopleuronectes americanus*, in Long Pond, Cenception Bay, Newfoundland. Journal of Fisheries Resource Board of Canada. 28: 1153-1165.

Ken Schultz.com. Angler's Encyclopedia. 2001.
http://www.kenschultz.com

Langston, R.W. and R.E. Bowman. 1980. Food of fifteen northwest Atlantic gadiform fishes. NOAA Technical Report. NMFS SSRF-740. 23 pp.

Laurence, G.C. 1975. Laboratory growth and metabolism of the winter flounder, *Psuedopleuronectes americanus*, from hatching through metamorphosis at three temperatures. Marine Biology. 32: 223-229.

Lavenda, N. 1949. Sexual differences and normal protogynous hermaphroditism in the Atlantic sea bass, *Centropristes striatus*. Copeia 1949 (3): 185-194.

Leim, A.H. and W.B. Scott. 1966. Fishes of the Atlantic coast of Canada. Bulletin of Fisheries Resources Board of Canada. 155: 484 pp.

MacKenzie, C. and J.R. Moring. 1985. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)—American lobster. U.S. Fish and Wildlife Service Biological Report 82(11.33). U.S. Army Corps of Engineers, TR EL-82-4. 19 pp.

MacKenzie, C., L.S. Weiss-Glanz, and J.R. Morning. 1985. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic)—American shad. U.S. Fish and Wildlife Service Biological Report. 82(11.37). U.S. Army Corps of Engineers. TR EL-82-4. 18 pp.

Martin, F.D. and G.E. Drewry. 1978. Development of fishes of the Mid-Atlantic Bight. An atlas of egg, larval, and juvenile stages. Vol. 6: Stromateidae through Ogcocephalidae. U.S. Fish and Wildlife Service Biological Services Program. FWS/OBS-78/12. 416 pp.

Mather, F. J., lll, H. L. Clark and J. M. Mason, Jr. 1975. Synopsis of the biology of the white marlin *Tetrapturus albidus* Poey (1861). Pages 55-94 *in:* Shomura, R. S. and F. Williams. eds. Proceedings of the International Billfish Symposium Kailua-Kona, Hawaii, 9-12 August 1972. Part 3. Species Synopses. NOAA Tech. Rep. NMFS SSRF-675. 159 p.

Maurer, R. 1975. A preliminary description of some important feeding relationships. International Committee of the Northwest Atlantic Fisheries (ICNAF) Resource Document. 75/IX/130.

Mayo, R.K., J.M. McGlade, and S.H. Clark. 1989. Patterns of exploitation and biological status of pollock (*Pollachius virens*) in the Scotian Shelf, Georges Bank, and Gulf of Maine area. Journal of the Northwest Atlantic Fisheries Sciences. 9: 13-36.

Mayo, R. 1994. Life histories and habitat requirements of demersal fishes. In R.W. Langton, J.B Pearce, and J.A. Gibson eds. Selected living resources, habitat conditions, and human perturbations of the Gulf of Maine: Environmental and ecological considerations for fishery management. P.2-3. NOAA Technical Memorandum NMFS-NE-106.

McBride, R.S. and D.O. Conover. 1991. Recruitment of young-of-the-year bluefish *Pomatomus saltatrix* to the New York Bight: variation in abundance and growth of spring-and summer-spawned cohorts. Marine Ecology Progress Series. 78: 205-216.

McCracken, F.D. 1963. Seasonal movements of the winter flounder, *Pseudopleuronectes americanus*, (Walbaum) on the Atlantic coast. Journal of Fisheries Resource Board of Canada. 20: 551-586.

McGowan, M. F. and W. J. Richards. 1989. Bluefin tuna, *Thunnus thynnus*, larvae in the Gulf Stream off the southeastern United States: satellite and shipboard observations of their environment. Fish. Bull. 87: 615- 631.

McMahon, J.J. and W.C. Summers. 1971. Temperature effects on the developmental rate of squid (*Loligo pealei*) embryos. Biological Bulletin (Woods Hole). 141: 561-567.

Mercer, L.P. 1978. The reproductive biology and population dynamics of black sea bass, *Centropristis striata*. Ph.D. dissertation, College of William and Mary, Williamsburg, VA. 195 pp.

Mercer, L.P. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic)—weakfish. U.S. Fish and Wildlife Service Biological Report. 82(11.109). U.S. Army Corps of Engineers, TR EL-82-4. 17 pp.

Messieh, S.N. 1988. Spawning of the Atlantic herring in the Gulf of St. Lawrence. American Fisheries Society Symposium. 5: 31-48.

Mid-Atlantic Fishery Management Council. [MAFMC]. 1996. Amendment #6 to the Fishery Management Plan and the Final Environmental Impact Statement for the Atlantic mackerel, squid, and butterfish fisheries. September 1996. MAFMC. [Dover, DE].

Moore, E. 1947. Studies on the marine resources of southern New England. VI. The sand flounder, *Lophopsetta aquosa* (Mitchell); a general study of the species with special emphasis on age determination by means of scales and otoliths. Bulletin of the Bingham Oceanographic Collection. 11(3): 1-79.

Morse, W.W. and K.W. Able. 1995. Distribution and life history of windowpane, *Scophthalmus aquosus*, off the northeastern United States. Fisheries Bulletin (U.S.) 93: 675-693.

Mullen, D.M., C.W. Fay, and J.R. Moring. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)—alewife/blueback herring. U.S. Fish and Wildlife Service Biological Reports 82(11.56). U.S. Army Corps of Engineers, TR EL-82-4. 21 pp.

Musick, J.A. and L.P. Mercer. 1977. Seasonal distribution of black sea bass, *Centropristis striata*, in the Middle-Atlantic Bight with comments on the ecology and fisheries of the species. Transactions of the American Fisheries Society. 106: 12-25.

National Oceanographic and Atmospheric Administration. [NOAA]. 1998. Guide to Essential Fish Habitat Designations in the Northeastern United States. Vol. III: Massachusetts, Connecticut and New York. NOAA/NMFS Habitat Conservation Division. 104 pp.

National Oceanic and Atmospheric Administration. [NOAA]. 1999a. Highly migratory species, fisheries management plan for Atlantic tunas, swordfish and sharks. NOAA/NMFS Technical Document. 250+pp.

National Oceanic and Atmospheric Administration. [NOAA]. 1999b. Essential fish habitat source document: red hake, *Urophycis chuss*, life history and habitat characteristics. National Marine Fisheries Service, Northeast Region, Woods Hole, Massachusetts. 34 pp.

Nesbit, R.A. and W.C. Nevill. 1935. Conditions affecting the southern winter trawl fishery. U.S. Department of Commerce. Circulation No. 18. 12 pp.

Oanie, D.S., J.G. Trial, and J.G. Stanley. 1984. Species profiles: life histories and environmental requirements of coastal fish and invertebrates (North Atlantic)—Atlantic salmon. U.S. Fish and Wildlife Service. FWS/OBS-82/11.22. U.S. Army Corps of Engineers. TR EL-82-4. 19 pp.

O'Brien, L., J. Burnett and R. K. Mayo. 1993. Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990. NOAA Technical Report, NMFS 113. 66 pp.

Ojeda, F.P. and J.H. Dearborn. 1990. Diversity, abundance, and spatial distribution of fishes and crustaceans in the rocky subtidal zone of the Gulf of Maine. Fisheries Bulletin (U.S.). 88: 403-410.

Oliver, J.D., M.J. Van Den Avyle, and E.L. Bozeman, Jr. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic)—bluefish. U.S. Fish and Wildlife Service Biological Report. 82(11.96). U.S. Army Corps of Engineers. TR EL-82-4. 13 pp.

Olla, B.L., R. Wicklund, and S. Wilk. 1969. Behavior of winter flounder in a natural habitat. Transactions of the American Fisheries Society. 98: 717-720.

Olla, B.L., C.E. Samet, and A.L. Studholme. 1972. Activity and feeding behavior of the summer flounder (Paralichthys dentatus) under controlled laboratory conditions. Fisheries Bulletin (U.S.) 70: 1127-1136.

Olla, B.L., A.J. Bejda, and A.L. Studholme. 1976. Swimming speeds of Atlantic mackerel, *Scomber scombrus*, under laboratory conditions: relation to capture by trawling. International Committee of the Northwest Atlantic Fisheries Resources Document 76/XII/143. 6pp.

Packer, D.B., S.J. Griesbach, P.L. Berrien, C.A. Zetlin, D.L. Johnson, and W.W. Morse. 1999. Essential Fish Habitat Source Document: Summer flounder, *Paralichthys dentatus*, life history and habitat characteristics. NOAA Technical Memorandum NMFS-NE-151. 90 pp.

Pearcy, W.G. 1962. Ecology of an estuarine population of winter flounder, *Psuedopleuronectes americanus* (Walbaum). Parts I-IV. Bulletin of the Bingham Oceanographic Collection. 18(1): 5-78.

Pepin, P., J.A. koslow, and S. Pearre, Jr. 1988. Laboratory study of foraging by Atlantic mackerel, *Scomber scombrus*, on natural zooplankton assemblages. Canadian Journal of Fisheries and Aquatic Sciences. 45: 879-887.

Pereira, J.J., R. Goldberg, J.J. Ziskowski, P.L. Berrien, W.W. Morse, and D.L. Johnson. 1999. Essential Fish Habitat Source Document: Winter Flounder, *Pseudopleuronectes americanus*, life history and habitat characteristics. NOAA Technical Memorandum NMFS-NE-138. 60+ pp.

Perlmutter, A. 1939. A biological survey of the salt waters of Long Island, 1938. An ecological survey of young fish and eggs identified from tow-net collections. 28th Annual Report New York State Conservation Department, Supplement. Part II: 11-71.

Reid, R.N., A.B. Frame, and A.D. Draxler. 1979. Environmental Baselines in Long Island Sound, 1972-1973. NOAA Technical Report. NMFS SSRF-738. 31 pp.

Reid, R., F. Almeida, and C. Zetlin. 1999. Essential Fish Habitat Source Document: Fishery independent surveys, data sources, and methods. NOAA Technical Memorandum. NMFS-NE-122. 39 pp.

Reid, R.N., L.M. Cargnelli, S.J. Griebach, D.B. Packer, D.L. Johnson, C.A. Zetlin, W.W. Morse, and P.L. Berrien. Essential Fish Habitat Source Document: Atlantic herring, *Clupea harengus*, life history and habitat characteristics. NOAA Technical Memorandum, NMFS-NE-126. 35 pp.

Roberts, J.L. 1975. Active branchial and ram gill ventilation in fishes. Biological Bulletin (Woods Hole) 148: 85-105.

Rogers, S.G. and M. J. Van Den Avyle. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic)—Atlantic menhaden. U.S. Fish and Wildlife Service, Division of Biological Services. FWS/OBS-82/11.11. U.S. Army Corps of Engineers, TR EL-82-4. 20 pp.

Scott, W.B. and M.G. Scott. 1988. Atlantic fishes of Canada. Canadian Bulletin of Fisheries and Aquatic sciences. 219. 731 pp.

Sette, O.E. 1943. Biology of Atlantic mackerel (*Scomber scombrus*) of North America. Part I: Early life history including growth, drift, and mortality of the egg and larval populations. U.S. Fisheries and Wildlife Service Fisheries Bulletin. 50: 1549-237.

Sette, O.E. 1950. Biology of Atlantic mackerel (*Scomber scombrus*) of North America. Part II. Migrations and habits. U.S. Fisheries and Wildlife Service Fisheries Bulletin. 51: 251-358.

Sherman, K. and H.C. Perkins. 1971. Seasonal variations in the food of juvenile herring in coastal waters of Maine. Transactions of the American Fisheries Society. 100: 121-124.

Short, F.T. ed. 1992. The ecology of the Great Bay Estuary, New Hampshire and Maine: an estuarine profile and bibliography. Jackson Estuarine Laboratory Contribution No. 264. Jackson Estuarine Laboratory, University of New Hampshire, Durham, NH. 222 pp.

Sinderman, C.J. 1979. Status of northwest Atlantic herring stocks of concern to the United States. U.S. National Marine Fisheries Center. Sandy Hook Laboratory Technical Series Report 23. 449 pp.

Smith, W.G., J.D. Sibunka, and A. Wells. 1975. Seasonal distributions of larval flatfishes (Pleuronectiformes) on the continental shelf between Cape Cod, Massachusetts and Cape Lookout, North Carolina, 1965-1966. NOAA Technical Report. NMFS SSRF-691.68 pp.

Steele, D.H. 1963. Pollock (*Pollachius virens*) in the Bay of Fundy. Journal of Fisheries Resources Board of Canada. 20: 1267-1314.

Steimle, F.W., D. Jeffress, S.A. Fromm, R.N. Reid, J.J. Vitaliano, and A. Frame. 1993. Predator-prey relationships of winter flounder, *Pleuronectes americanus*, in the New York Bight apex. Fisheries Bulletin U.S. 92: 608-619.

Steimle, F.W., C.A. Zetlin, P.L. Berrien, D.L. Johnson, and S. Chang. 1999a. *Essential Fish Habitat Source Document:* Red Hake (*Urophycis chuss*), Life History and Habitat Characteristics. U.S. Dept. Commer., NOAA Technical Memorandum NMFS-NE-149.

Steimle, F.W., C.A. Zetlin, P.L. Berrien, D.L. Johnson, and S. Chang. 1999b. *Essential Fish Habitat* Source Document: Black Sea Bass, *Centropristis striata*, Life History and Habitat Characteristics. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-NE-143.

Steiner, W.W., J.J. Luczkovich, and B.L. Olla. 1982. Activity, shelter usage, growth and recruitment of juvenile red hake, *Urophycis chuss*. Marine Ecology Progress Series. 7: 125-135.

Studholme, A.L., D.B. Packer, P.L. Berrien, D.L. Johnson, C.A. Zetlin, and W.W. Morse. 1999. Essential Fish Habitat Source Document: Atlantic mackerel, *Scomber scombrus*, life history and habitat characteristics. NOAA Technical Memorandum NMFS-NE-141. 40 pp.

Suda, A. 1994. Some preliminary observations on the biological characteristics of the concentrations of bluefin tuna in the Northwestern and Central North Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 42(1) : 267-270.

Tiews, K. 1963. Synopsis of biological data on the bluefin tuna *Thunnus thynnus* (Linnaeus) 1758 (Atlantic and Mediterranean). Pages 422- 481 in: H. Rosa Jr. ed. Proceedings of the World Scientific Meeting on the Biology of Tunas and Related Species. FAO Fisheries Reports No. 6 (2).

USFWS (United States Fish and Wildlife Service). 1996. 1994 Survey of Atlantic salmon in two tributaries, Kennebec River, Maine. Office of Fishery Assistance, USFWS, Laconia, New Hampshire.

Van Den Avyle, M. 1984. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic) -- Atlantic Sturgeon. U.S. Fish and Wildlife Service Biol. Rep. 82(11.25) pp 17.

Vecchione, M. 1981. Aspects of the early life history of *Loligo pealei* (Cephalopoda: Myopsida). Journal of Shellfish Resources. 1: 171-180.

Vecchione, M., C.F.E. Roper, and M.J. Sweeney. 1989. Marine flora and fauna of the eastern United States Mollusca: Cephalopoda. NOAA Technical Report NMFS 73. 23 pp.

Vinnichenko, V. I. 1996. New data on the distribution of some species of tuna (*Scombridae*) in the North Atlantic. J. of Ichth. 36(8): 679-681.

Vovk, A.N. and L.A. Khvichiya. 1980. On feeding of long-finned squid (*Loligo pealei*) juveniles in Subareas 5 and 6. Northwest Atlantic Fisheries Organization (NAFO) Science Council Resource Document. 80/VI/50. 9 pp.

Wahle, R. A. and R. S. Steneck. 1991 Recruitment habitats and nursery grounds of the American lobster (Homarus americanus Milne Edwards): A demographic bottleneck? Marine Ecology Progress Series. 69: 231 243.

Ware, D.M. and T.C. Lambert. 1985. Early life history of Atlantic mackerel (*Scomber scombrus*) in the southern Gulf of St. Lawrence. Canadian Journal of Fisheries and Aquatic Sciences. 42: 577-592.

Waring, G.T. and S. Murawski. 1982. Butterfish. In M.D. Grosslein and T.R. Azarovitz eds. Fish distribution. P. 105-107. MESA New York Bight Atlas Monograph 15. N.Y. Sea Grant Institute. Albany, NY.

Weiss-Glanz, L.S., J.G. Stanley, and J.R. Moring. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)—American shad. U.S. Fish and Wildlife Service Biological Report. 82(11.59). U.S. Army Corps of Engineers, TR EL-82-4. 16 pp.

Wheatland, S.B. 1956. Pelagic fish eggs and larvae. *In* G.A. Riley *et al.* Eds. Oceanography of Long Island Sound, 1952-1954. P. 234-314. Bulletin of the Bingham Oceanographic Collection. 15.

Wilk, S.J., W.W. Morse, and L.L. Stehlik. 1990. Annual cycles of gonad-somatic indices as indicators of spawning activity for selected species of finfish collected from the New York Bight. Fisheries Bulletin (U.S.) 88: 775-786.

Wilk, S.J., W.W. Morse, and D.E. Ralph. 1978. Length-weight relationships of fishes collected in the New York Bight. Bulletin of the New Jersey Academy of Sciences. 23(2): 58-64.

Witting, D.A., and K.W. Able. 1995. Predation by sevenspine bay shrimp, *Crangon septemspinosa*, on winter flounder, *Pleuronectes americanus*, during settlement: laboratory observations. Marine Ecology Progress Series. 123: 23-31.

www.fishbase.org. 2001.

Young, R.E. and R.F. Harman. 1988. “Larva”, “paralarva”, and “subadult” in cephalopd terminology. Malacolgia. 29: 201-207.