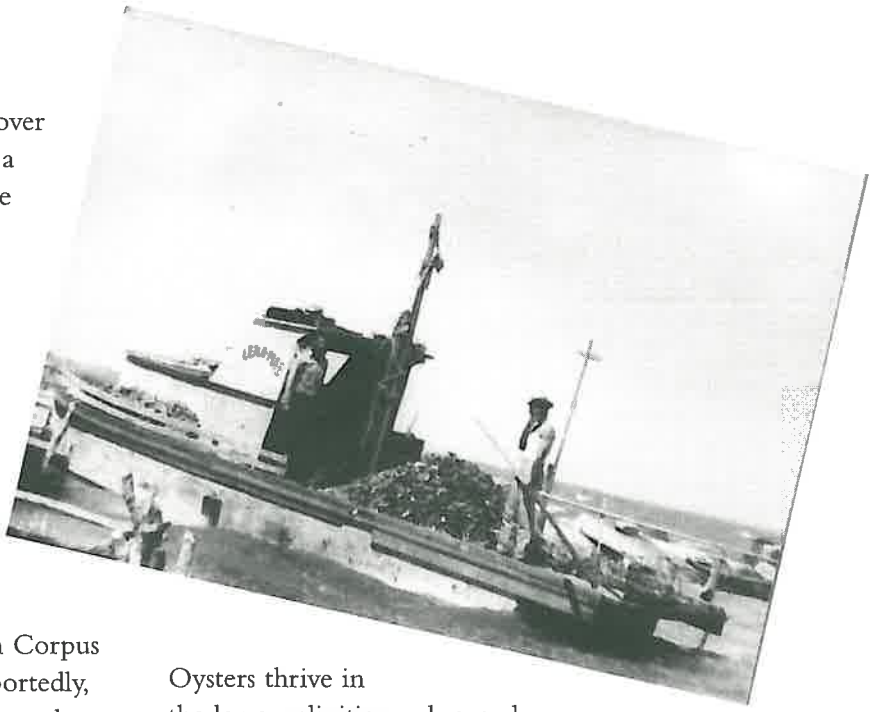
grounds to start the cycle over again. Thus, tidal inlets are a critical link in the life cycle of most commercial and recreational fish and shellfish species.



Oyster Reefs and other Hard-Substrate Habitats

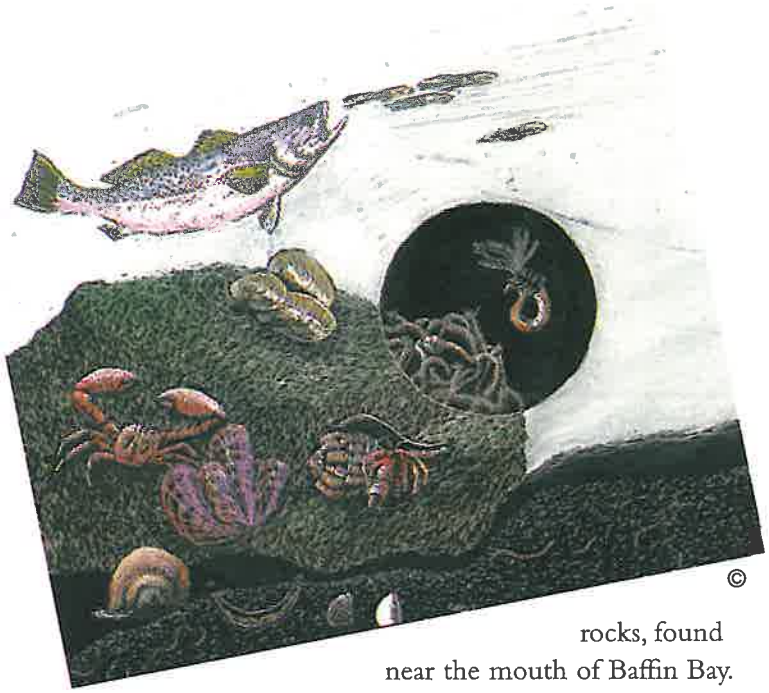
As recently as the mid-1800s, a large oyster reef spanned the mouth of Nueces Bay and served as a bridge between Corpus Christi and Portland. Reportedly, oyster reefs were originally so dense in northern Aransas Bay that the Indians could cross the 10 miles from Lamar Peninsula to San Jose Island on foot by simply following the reefs. Most of this material must have been removed by shell dredging. Removing the shell enhanced water exchange between Nueces and Corpus Christi Bays and between San Antonio and Aransas Bays. Shell removal may have increased the volume of water in Nueces Bay by as much as 50 percent.

Today, extensive live oyster reefs are found primarily in the northern portion of the Coastal Bend, especially in Mesquite, Copano, and northern Aransas Bays where higher freshwater inflow maintains moderate salinities. Salinities in these bays are typically 10 to 20 parts per thousand (ppt), whereas salinities in Corpus Christi and Nueces Bays are typically 20 to 30 ppt, and often over 40 ppt in upper Laguna Madre and Baffin Bay. Oysters thrive in the lower salinities and several oyster predators, especially the oyster drill snail, cannot tolerate this condition. Although scattered oysters and small reefs can still be found in Corpus Christi Bay, most of these reefs are currently dead or even buried.

Extensive shell dredging operations were conducted in the 1930s and 1940s throughout the Coastal Bend. Regulations imposed in the 1950s and 1960s to eliminate the damage to living reefs and adjacent bay bottoms finally brought the practice to an end by the mid 1970s. It is not precisely known how much shell was removed but records indicate that, in this century, 24 million cubic yards of shell were removed from Nueces Bay alone. More shell may have been taken from bays in the northern part of the Coastal Bend.

One type of fairly extensive natural hard bottom in the Coastal Bend is the serpulid reefs, or worm

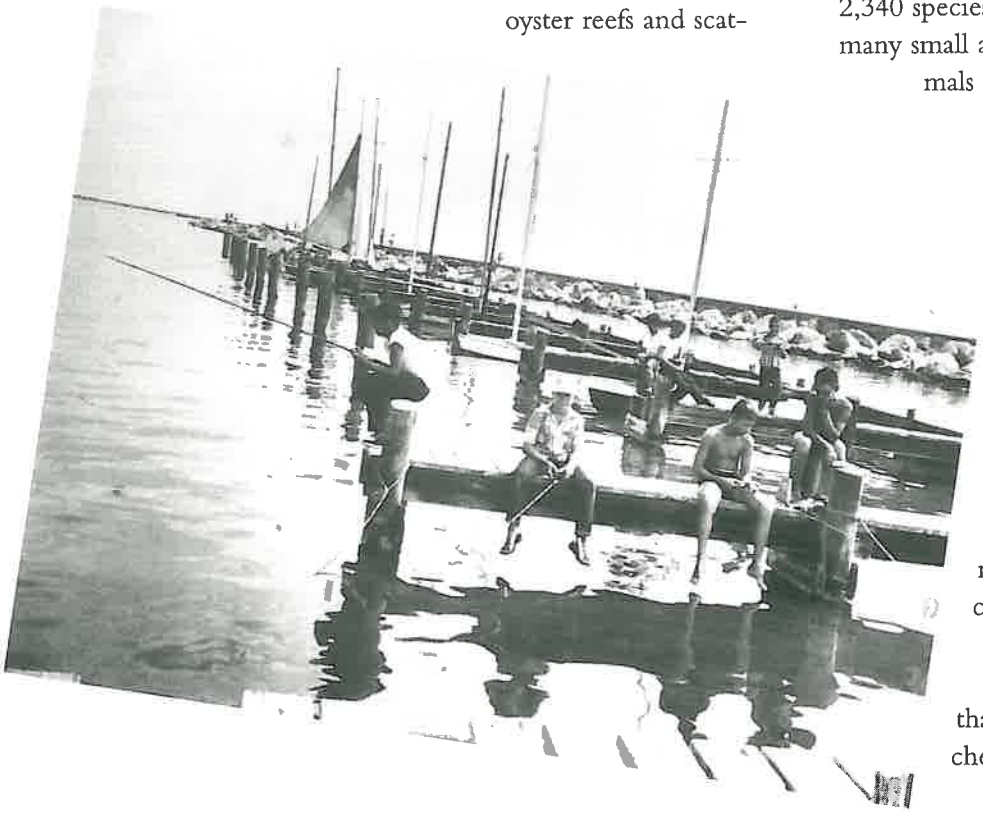
Oyster shell, or mudshell as it was called in the industry, has been a common building and paving material since the beginning of European settlement. It was mixed as "shell-crete" for building material and crushed for use as paving material for streets and driveways. Historically, the shell was easily dug from live and buried reefs in shallow water and "ancient" reefs on land. Actually many of these "paleo-reefs" were not actual reefs but old Indian middens. It was reported that, in the 1920s, arrowheads could frequently be found on the streets of Rockport after they were repaved with shell.



rocks, found near the mouth of Baffin Bay. These reefs, covering about 4,000 acres, are formed from the hardened tubes of polychaete worms and are estimated to have been built around 3,000 years ago. Although some additional growth may have taken place during the past 300 years, there are few if any worms living on the reefs today.

Overall, about 18 percent of the Coastal Bend shoreline has been converted to hardened shoreline.

Aside from the widespread oyster reefs and scattered serpulid worm reefs in the upper Laguna Madre and Baffin Bay, hard bottom habitats are relatively rare in the Coastal Bend. Artificial, human-made structures such as jetties, groins, breakwaters, and bulkheads make up the majority of hard substrate habitat. These structures can replace seagrass, marsh, and tidal flat habitats as a result of shoreline development. Over one-half of the shorelines of Corpus Christi, Nueces, and Oso Bays has been altered in the past century, and much of this area has been converted to hardened shoreline.



Living Resources

The most recent and comprehensive list of the living resources found in the Coastal Bend includes at least 835 species of plants associated with bays and marshes and over 2,340 species of animals. Since many small and inconspicuous animals have not been identified and catalogued, the actual number of species may be as high as 5,000. In addition to the tremendous aesthetic, recreational, and commercial values associated with these living resources, they are also sources of current and future medicinal, industrial, and agricultural products.

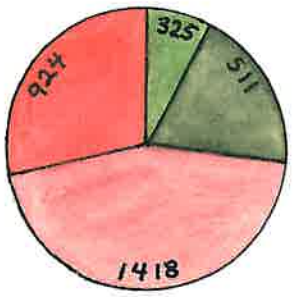
Scientists believe that the natural system of checks and balances is

dependent on maintaining biological diversity, or the number of species found within a defined geographical area. Biological diversity of the aquatic and adjacent terrestrial ecosystems is increasingly threatened by the impacts of large numbers of people living, working, and playing near coastal areas. Biological diversity can also be affected by human activities within the larger watershed region that drains into our bays and estuaries.

Fishes

Fishes are a very diverse group of animals. They can be found throughout the estuaries: some are water column dwellers, some live among seagrass blades in the shallow flats, and others prefer open water bottoms, oyster reefs, or the surf zone along the beach. The habitat occupied by a fish may change over its lifetime. For example, juvenile stages of many species are found in estuarine seagrass meadows while the adults live offshore.

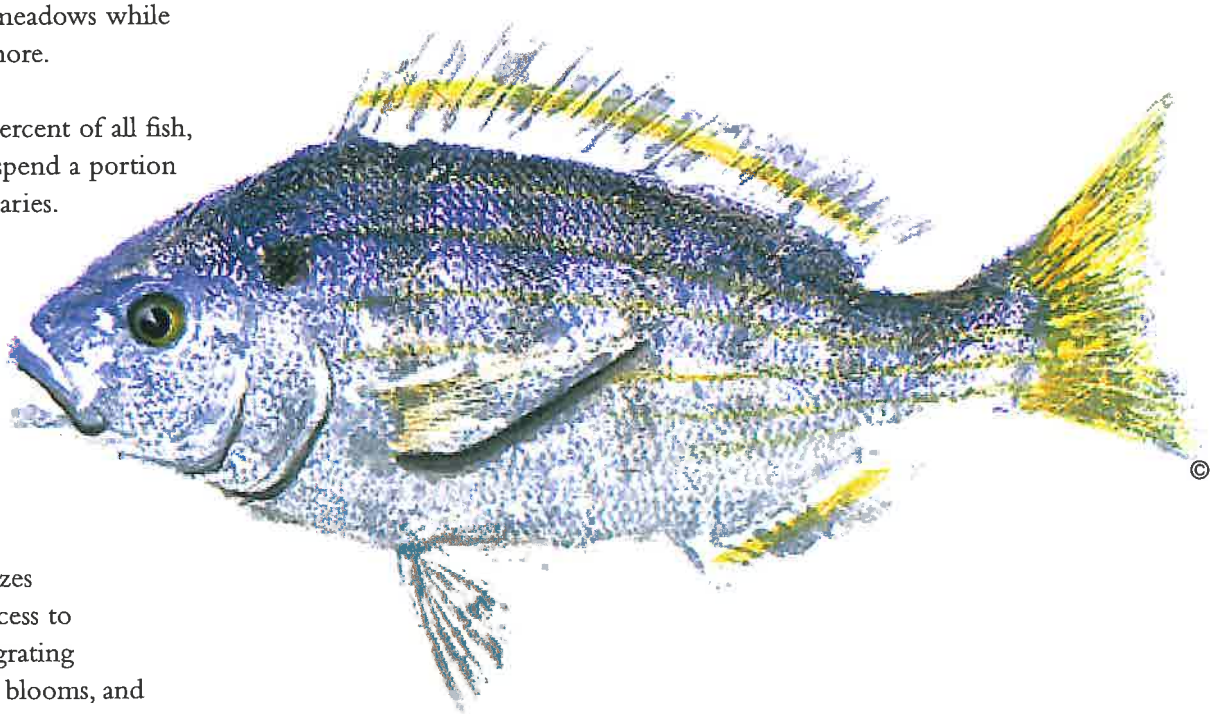
Over 80 percent of all fish, crabs, and shrimp spend a portion of their life in estuaries. The abundance of fish within a particular estuary can be influenced by both natural and human factors. Natural factors include weather events such as freezes and hurricanes, access to tidal passes for migrating species, toxic algal blooms, and salinity. The amount of freshwater inflow into an estuary, which plays a crucial role in the health of the system, is determined by both natural rainfall patterns and human modifications within the watershed. Other human-related factors affecting fish populations include overfishing, pollution, and habitat loss and degradation.



Species composition in Coastal Bend Region
- Algae
- Vascular plants
- Invertebrates
- Vertebrates

The Coastal Bend is one of the richest sources of fisheries in Texas. Between 1972 and 1992, an average of 8.4 million pounds per year of finfish, shrimp, crabs, and other aquatic species were reported as commercially harvested. Although the proportions of finfish, shrimp, and blue crab harvested in

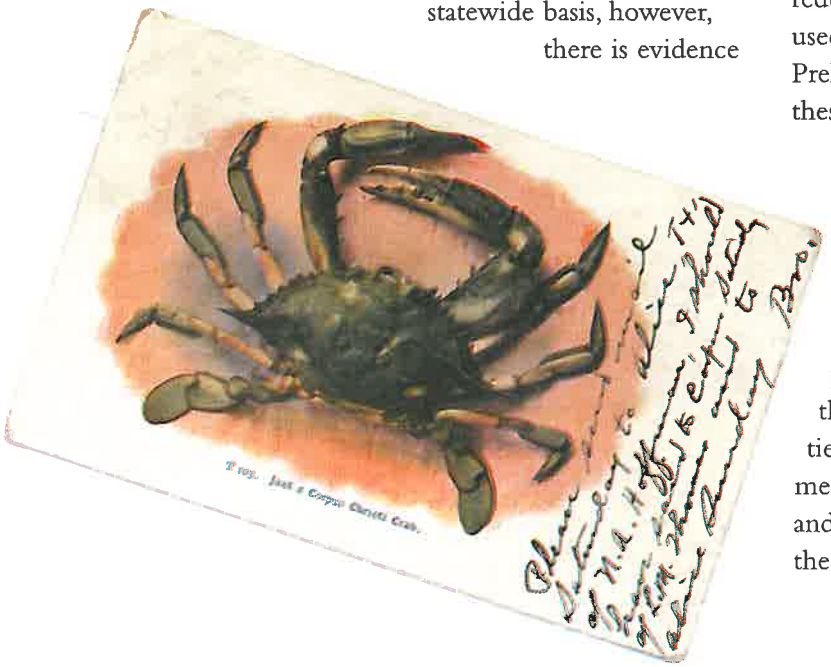
Management and Conservation of Populations - Living resources are currently managed with the goal to use them in a renewable and sustainable fashion and to preserve species diversity. The target of most living resource management plans is human activity. Regulation may be required to avoid the over-harvesting of living resources, particularly in heavily populated areas.



The Texas commercial shrimping industry increased dramatically in the 1920s, when trawling gear towed by motorized vessels began to be used. Shrimping has since become the largest food fishery in the state. In 1993, 74 million pounds of shrimp were landed statewide with an estimated economic value of $500 million.

the early 1970s were roughly similar, today's fishing industry is dominated by shrimp harvesting.

Between 1988 and 1993, reported shrimp landings in the Coastal Bend ranged between 60 and 90 percent of the total commercial seafood harvest. Most inshore shrimp harvested in the Coastal Bend are from the Aransas and Corpus Christi estuaries; reported landings in the upper Laguna Madre are mostly finfish. Even though total shrimp landings in the Coastal Bend are known, it is difficult to evaluate the status of the population through time. On a statewide basis, however, there is evidence that, although the intensity of bay shrimping has increased dramatically, individual shrimping vessels must currently fish for more hours to obtain the same catch as 20 years ago. If this statewide trend applies to the Coastal Bend, shrimpers are fishing harder to catch fewer shrimp.



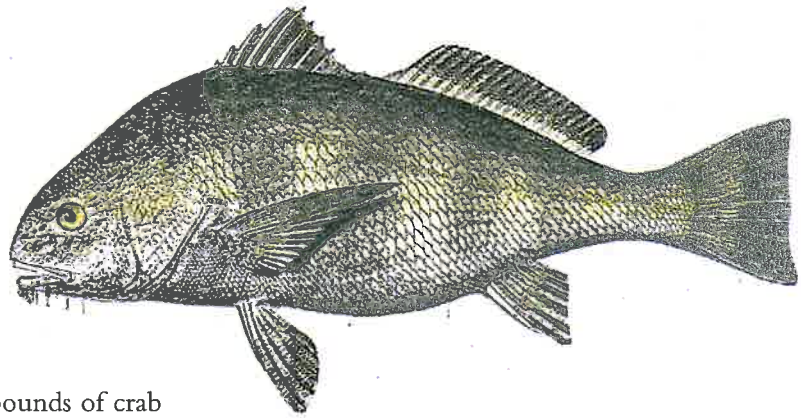
One impact of shrimping is the catch of unintended species, or bycatch. Bycatch from the shrimping industry includes finfish, crabs, starfish, and squid. One study indicates that finfish bycatch comprised between 1.5 and 7 times the weight of the shrimp caught in the Aransas and Corpus Christi estuaries. Although most bycatch is returned to the water, there is little scientific information as to what proportion of the bycatch actually survives. Casual observation suggests that, other than crabs, few animals probably survive shrimp boat handling and culling. A cooperative study between the CBBEP, the shrimping industry, and Texas Parks and Wildlife is testing several bycatch reduction devices (BRDs) on nets used in the Coastal Bend. Preliminary results indicate that these devices hold promise in reducing the unwanted catches from shrimp nets.

Other impacts of shrimp trawling include the alteration of species abundance and composition on the bay bottoms and the resuspension of large quantities of sediments. Suspended sediment can smother marine organisms and lead to excessive nutrients in the water. Unfortunately, there is lit-

tle information on the extent or long-term consequences of these environmental impacts, either at the local or national levels.

The commercial finfish catch within the Coastal Bend comprised about half the catch of all Texas bays between the 1970s and early 1990s. The finfish catch declined sharply after 1979 due to drops in population caused, in part, by overfishing. In response, a statewide ban on the commercial harvest of red drum and spotted seatrout was introduced in 1981. The commercial finfish catch was about 3 million pounds in 1996, made up primarily of black drum taken from the upper Laguna Madre.

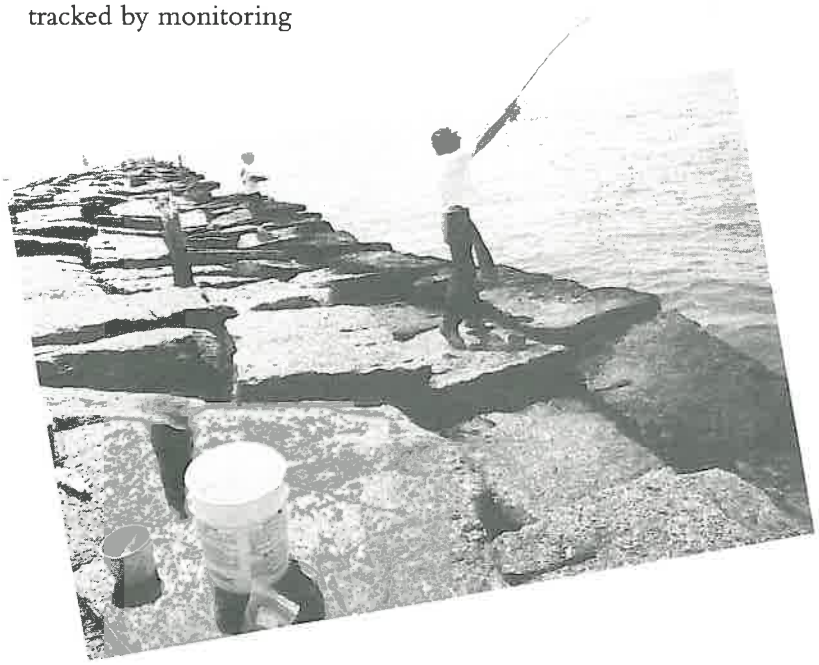
Although shrimp and finfish are the most sought-after species in the Coastal Bend, blue crabs and, to a lesser extent, oysters are also commercially important. Blue crab harvesting in the Coastal Bend region provided about a fourth of the state's total reported catch between 1972 and 1992; between 1.5 and 1.8 million pounds of crab were harvested each year. On the other hand, Coastal Bend oysters provide a fairly small fraction of the total harvest in Texas.



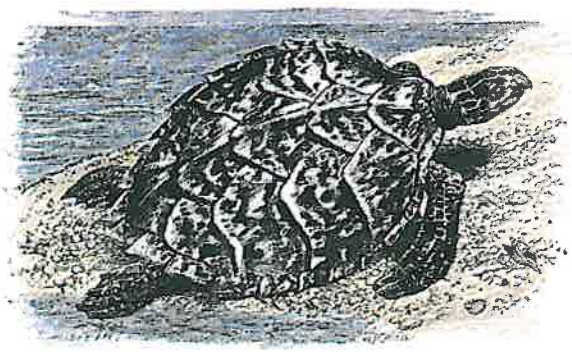
The recreational fishery in the Coastal Bend contributed about 28 percent of the total catch in all Texas bays between 1976 and 1991. Over this same time frame, the amount of sport-fishing activity has generally increased while the number of fish landed has decreased. This decline in landings is due mainly to more restrictive size and catch limits for desirable species such as red drum and spotted seatrout.

Trends in the population size of fish and shellfish can be tracked by monitoring

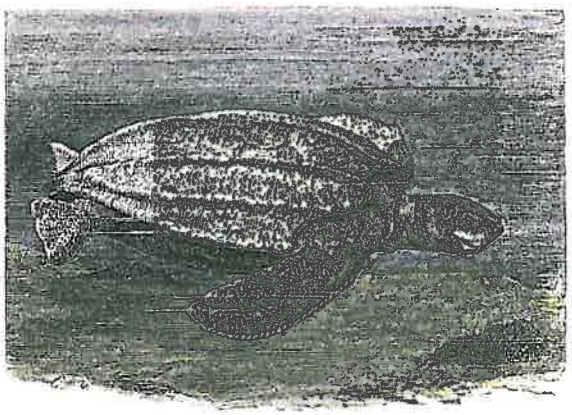
The economic impact of the commercial and recreational fisheries, both harvest and sales, along the Texas coast is in excess of $2 billion a year. Tens of thousands of jobs are associated with the industry. Historically, as the human population density has increased along the coast, demand for fisheries resources has expanded. Fishing efforts have increased to meet this demand and, in some fisheries, technological advances have yielded larger returns for less effort.



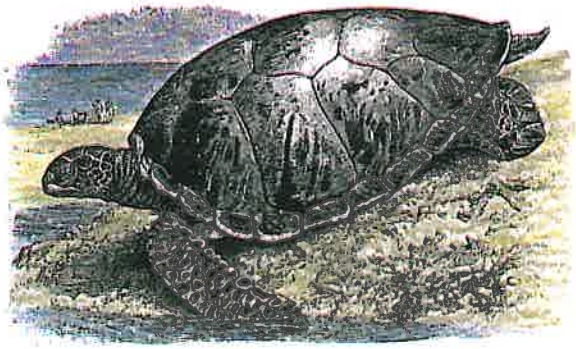
Sea turtles vary widely in size. An adult Kemp's ridley is relatively small at 26 inches, whereas the largest living turtle, the leatherback, can measure up to 6 feet in shell length and weigh about 1,400 pounds. Female turtles must be at least 20 years old before they are capable of egg-laying. Given this long maturation period, turtle populations are very susceptible to human disturbances.



Hawksbill Turtle



Leatherback Turtle



Green Turtle

Fish and shellfish are potentially renewable resources. They can respond to positive management actions fairly rapidly as long as sufficient quality habitat is available. Without suitable quality habitats, no management actions are likely to restore and maintain diminished populations.

An endangered species is "any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man."

catches in the commercial and recreational fishery and by direct sampling of these resources by scientists. The latter method provides so-called fisheries-independent data that is not influenced by changes in the activity or skill levels of commercial and recreational fishermen. Studies in the Coastal Bend over the past 20 years show that some species have prospered while others have declined. The numbers of adult black drum, spotted seatrout, and sub-adult red drum have generally increased over that time period as have the numbers of white shrimp. However, brown and pink shrimp, adult blue crabs, and Gulf menhaden have generally declined.

Sea Turtles

Although the Gulf of Mexico region once hosted significant populations of five species of marine turtles, today they are rare or absent in many areas. The hawksbill, loggerhead, leatherback, and Kemp's ridley sea turtles are currently considered endangered by the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (FWS) and Texas Parks and Wildlife. The Green sea turtle is considered threatened by these agencies.

A threatened species is "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."
From the Endangered Species Act of 1973.

In the mid-1800s, turtles were intensely harvested for meat and oil; four canneries existed along the Texas coast. In 1881, a cannery was established at Fulton, on Aransas Bay, and probably the majority of captured turtles for this plant were from Aransas Bay. The Green turtle was the leading marine product (by weight) harvested from Laguna Madre waters, although it is very likely that other species were harvested from these waters as well. Matagorda Bay and lower Laguna

Madre were also sources of sea turtles. Due to over-harvesting, the industry collapsed by the early 1900s.

From the 1940s to the 1960s, eggs of Kemp's ridley sea turtles were heavily exploited at their primary nesting site in Rancho Nuevo, Tamaulipas, Mexico, about 200 miles south of Brownsville. During the same period, fishing for finfish and shrimp increased along the Texas coast, and many turtles perished as bycatch in these fisheries. Today, Kemp's ridley is the most endangered turtle species of the Gulf of Mexico. It is believed that, of the nearly 40,000 females known to nest in Rancho Nuevo in the 1940s, only 700 females remain.

Despite the low number of adults, the nesting population at Rancho Nuevo has increased during the last two decades. This is largely due to collaborative conservation efforts by the U.S. and Mexican governments to protect the nesting sites. In addition, the National Marine Fisheries Service in 1987 implemented the use of Turtle Exclusion Devices (TEDs) that allow turtles to escape from fishing nets. Despite the use of TEDs, turtle strandings have been at near record levels for the past four years.

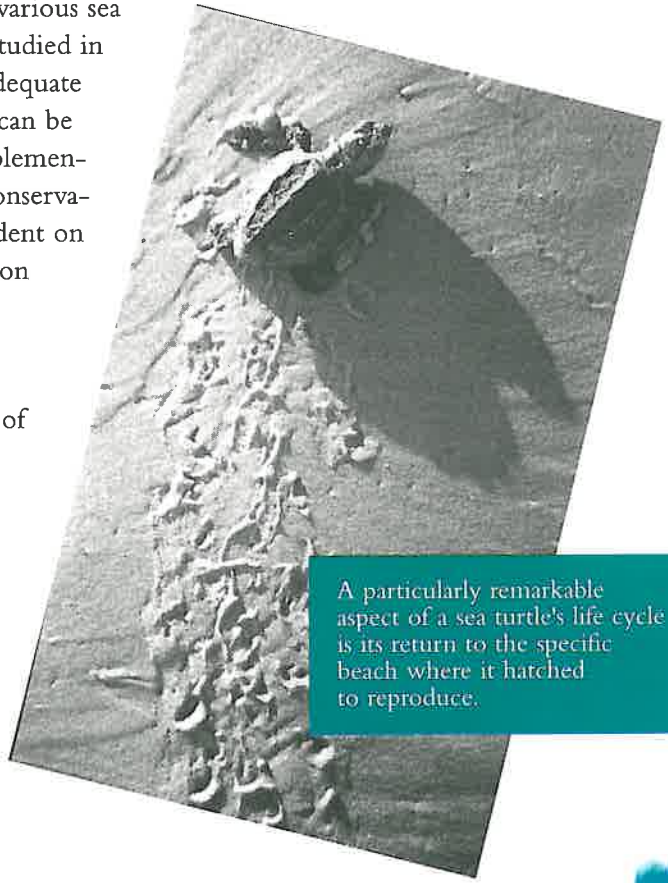
Sea turtle populations face a variety of additional threats: human population growth and development of coastal areas, dredging, beach cleaning, beach motor traffic, pollution, ingestion of debris, impact with boat hulls or propellers, artificial lighting, recreational beach equipment, and power plant entrapment. The ecology of various sea turtle species must be studied in greater detail, so that adequate conservation measures can be implemented. The implementation of appropriate conservation measures is dependent on ongoing public education and support.

There are 19 species of plants and animals found in the Coastal Bend that are classified as threatened or endangered.

Turtle eggs are considered a delicacy and the congregation of large numbers of reproducing females at one site has led to the collection of thousands of eggs and the destruction of entire generations of sea turtles, particularly the Kemp's ridley.

Marine mammals

People generally think of marine mammals as a particularly fascinating group of aquatic animals. And, because of similarities to humans, marine mammals are potentially susceptible to the same contaminants as humans.

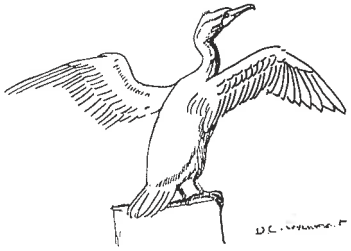


A particularly remarkable aspect of a sea turtle's life cycle is its return to the specific beach where it hatched to reproduce.

Rough-toothed

Atlantic spotted

Atlantic bottlenose



The first documented report of birds in the Coastal Bend is attributed to Alvar Nunez Cabeza de Vaca, the Spanish explorer who lived among Indian tribes in Central and South Texas between 1528 and 1536. By the late 19th century, explorers and historians such as George B. Sennett and Frank M. Chapman had documented the remarkable abundance of birds. The first reports of declining populations also correspond to that time period. In 1891, Chapman wrote about the negative consequences of hunting and collecting feathers for hat decoration.

The Atlantic bottlenose dolphin is the most common marine mammal in the Coastal Bend and is often observed feeding in the channels, bays, and even shallow areas. The population of this species appears stable, although counts are difficult because dolphin migrate between offshore areas and the bays. The Atlantic spotted dolphin and the rough-toothed dolphin are both listed as threatened species in Texas, although little is known about their abundance in the Coastal Bend.

A potential increase in the number of marine mammal strandings during the last few years has drawn considerable public attention. Animals are considered stranded when they are found either alive or dead on shore. Stranding incidents are reported to the Texas Marine Mammal Stranding Network which activates volunteers to investigate the stranding, provide aid to injured animals, and determine the cause of death if possible. The most commonly stranded species in the Coastal Bend is the bottlenose dolphin and usually only one animal is found at a time. Between January and April 1992, however, 83 bottlenose dolphins were stranded on Coastal Bend beaches, from unknown causes.

Stranded dolphins may suffer from diseases or wounds caused by boats, net entanglement, knives, or gunshots. Most dolphins, however, die of causes that cannot be readily determined. Both natural disturbances, such as freezes and diseases, and human-related disturbances, such as toxic contaminants in the environment, affect the health and status of marine mammals. There are no comprehensive studies of the extent of these effects in the Coastal Bend.

Birds

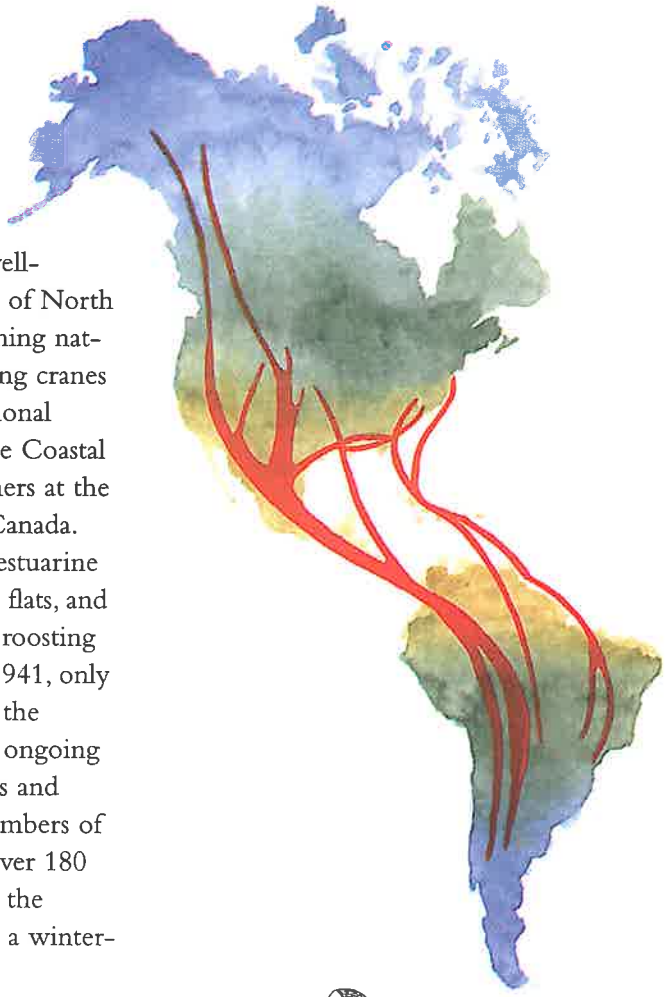
The Coastal Bend is a birder's paradise, providing a seasonal variety of colorful migrants, nesters, and local residents. In addition to their aesthetic value, birds provide recreational benefits as well as a natural check for insects and other pests.

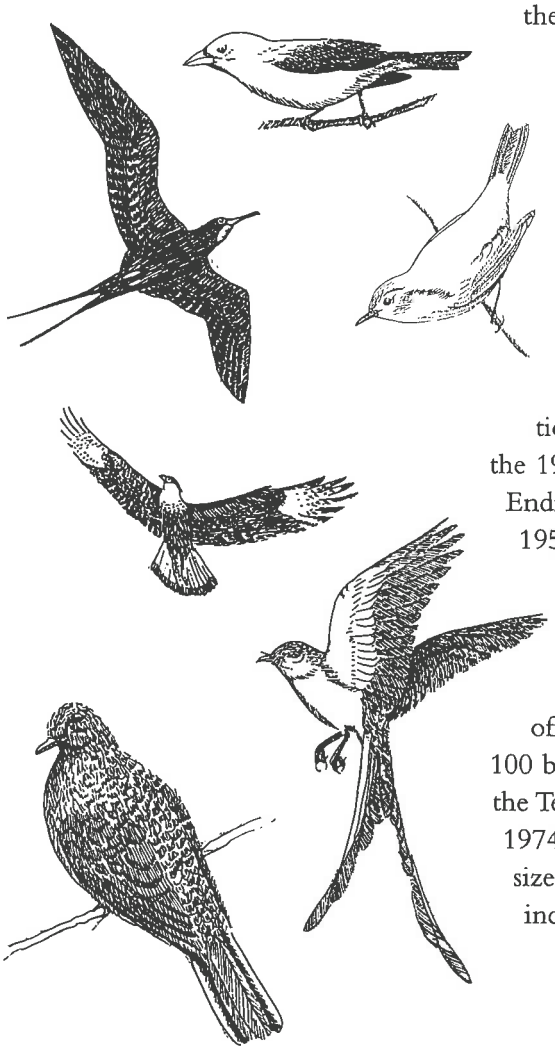
There are an astonishing 494 verified bird species living in or migrating through the Coastal Bend. An additional 38 species have been reported but these sightings have not yet been verified. To put these counts in perspective, it is estimated that the entire state of Texas hosts about 600 species of birds. The enormous diversity of bird species in the Coastal Bend is attributed to its key geographical location as a

stopover point for migrants. Additionally, there are numerous types of food for resident and migrant birds and many available feeding and nesting habitats, including Gulf beaches, prairies, oak mottes, flats, freshwater marshes, and urban land.

There are eight federally-listed endangered or threatened bird species in the Coastal Bend, including the whooping crane, piping plover, and brown pelican. These species are threatened by habitat loss and degradation, water conservation practices which may limit freshwater inflow to coastal habitats, contamination, and human disturbances such as boating and oil and gas operations.

The whooping crane is one of the most well-known endangered species of North America. The single remaining natural population of whooping cranes winters at the Aransas National Wildlife Refuge, within the Coastal Bend, and spends its summers at the Buffalo National Park in Canada. Whooping cranes require estuarine marshes, shallow bays, tidal flats, and upland rangeland areas for roosting and feeding in winter. In 1941, only 15 or 16 birds wintered at the Refuge. Due to extensive ongoing efforts by the United States and Canada to restore the numbers of these majestic birds, over 180 birds currently use the Coastal Bend as a wintering ground.





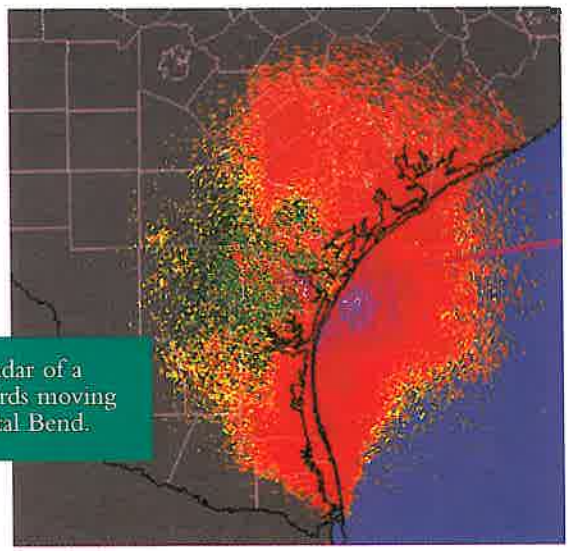
Another well-known endangered species found in the Coastal Bend is the brown pelican. Hunters and fishermen caused declines in populations of these birds prior to the 1930s. Use of the pesticide Endrin (containing DDT), in the 1950s, further decimated the populations of these birds. DDT accumulated in adult birds and resulted in eggshell thinning and high offspring mortality. Less than 100 brown pelicans nested along the Texas coast between 1967 and 1974. Since then, the population size of brown pelicans has increased. Pelican Island in

Bird surveys are conducted during certain times of the year to determine trends in the long-term abundance of selected species. One survey, the Christmas Bird Count (CBC) sponsored by the National Audubon Society, concentrates on species found in the Coastal Bend at the beginning of winter. Another, the Texas Colonial Waterbird Survey, focuses on 25 species of water birds that nest in the area.

Corpus Christi Bay now hosts about 50 percent of the nesting pairs in Texas.

Hunting led to a serious decline of piping plovers early in this century and further declines are associated with extensive loss of habitat. This species winters in coastal areas of the southern United States, especially Texas, and spends the summer months from Canada south to Nebraska and the Great Lakes. In the Coastal Bend, piping plovers depend on tidal flats and washover passes. The piping plover is listed as a threatened species and, it is believed that if the current declines continue, the species could go extinct within an 80 year period.

Some birds are highly valued as game species. Although there is little specific information regarding the economic impact of bird hunting in the Coastal Bend, hunting of all game species is a $1 billion a year industry in Texas. Among the 25 species hunted within the Coastal Bend are the greater white-fronted goose, snow goose, Canada goose, wood duck, mallard, mottled duck, northern pintail, redhead duck, ring-neck duck, blue-winged teal, wild turkey, bobwhite quail, and mourning dove.



Echoes on weather radar of a cloud of migrating birds moving on shore in the Coastal Bend.

The status of nesting populations of colonial water birds, including herons, egrets, gulls, and terns is currently unclear. Some decreasing trends recorded in nesting can be attributed to the degradation of nesting habitat and disturbance by humans or predators, while some increases in abundance, associated with seasonal counts such as the Christmas Bird Count, may be attributable to the range expansion of wintering species. Populations of some species of waterfowl and shorebirds are reportedly increasing while others, like the great egret, snowy egret, tricolored heron, redhead, gull-billed tern and Forster's tern are declining.

Neotropical migrant song birds in the Coastal Bend include various species of vireos, warblers, and sparrows. A positive trend in abundance of some of these species has been documented by the Christmas Bird Counts. However, the U.S. Fish and Wildlife Service has declared the study of neotropical migrants a priority due to the rapid loss of their habitat, particularly in Mexico.

Although progress has clearly been made in estimating the number of species and population sizes of birds within the Coastal Bend, it is evident that further work is still required. The number and species of birds migrating through the area during spring and fall are not well documented. Several Gulf-wide studies to understand and quantify migration across and around the Gulf of Mexico are in

progress.
Overall, there is insufficient information on the vast majority of species found in the Coastal Bend to determine population status and habitat needs.

Harmful Algal Blooms.

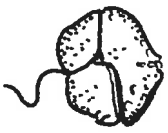
Algal blooms appear to be an increasingly common phenomena on a worldwide scale. Some blooms are considered harmful because of their potential threat to human health through the consumption of contaminated seafood, while others cause changes in the abundance and distribution of plants and animals. Two types of harmful algal blooms, red tides and brown tides, have affected the Coastal Bend in recent years. Although these particular names refer to the water discoloration that occurs during the bloom event, harmful algal blooms can be present without observable changes in water color.

There have been less than a dozen documented red tide blooms over the entire Texas coast and only one documented brown tide bloom. This brown tide bloom has persisted in Laguna Madre from January of 1990 to the summer of 1998. The bloom began in Baffin Bay, a system that was already stressed by persistent high salinities and reduced populations of organisms that could potentially feed on the brown tide algae. It has been suggested that the occurrence of two severe freezes in December of 1989, resulting in massive fish and shellfish kills, caused the release of a large nutrient pulse from the decomposing organisms and, in turn, fueled the initial bloom of the brown tide.

The brown tide reduced water clarity, shaded out seagrass beds, and disrupted sport fishing activities. Although there has been no apparent effect on populations of adult fish and shellfish, the brown tide is toxic to newly hatched fish larvae, and the densities of fish larvae appear to have declined in areas severely impacted by the brown tide.

Perhaps the most important unanswered question is: why did the brown tide persist for so long?

Bird Watching - Due to high species diversity, Texas is considered the foremost bird watching destination in the country. The Aransas National Wildlife Refuge and the Rockport-Fulton area, wintering ground of the endangered whooping crane and other migratory waterfowl, host between 75,000 and 100,000 tourists every year. The Hummingbird Celebration, held in Rockport, and the Whooping Crane Celebration, held in Port Aransas, attract thousands of visitors each year. Although few detailed studies are available, it has been estimated that $600 million per year is spent on equipment used for observation of all non-game species, much of which is associated with bird watching.



In the early 1990s, the organism causing the brown tide was unknown to the scientific community. Scientists have since shown that this organism is present at very low densities in other Texas estuaries and in Florida, but only in Laguna Madre did it bloom so persistently. The proposed name for this new species is Aureoumbra lagunensis.

The dinoflagellates responsible for the so-called red tides have pigments that can tint the water red during a bloom. Beachcombers notice red tides in other ways -- airborne toxins sting the insides of their noses and throats.

In recent times, red tides have become more frequent and more noticeable but they have been around at least since biblical times. In Exodus, a plague turned the water blood red and destroyed fish. Science News, Sept 27, 1997.

Spanish conquistadors found discolored water and dead fish in the Gulf of Mexico as early as 1530, and a massive 1935 fish kill near Corpus Christi was mistakenly blamed on an undersea volcanic eruption.
From the Harmful Algae Page
http://www.redtide.whoi.edu/hab/.

A variety of reasons have been suggested. The brown tide may suppress the growth of other phytoplankton and negatively affect organisms that would feed on it. Also, the lack of freshwater inflow to Laguna Madre and the restricted exchange of water with the Gulf of Mexico make it difficult to disperse an algal bloom once it becomes established.

Red tides are caused by a type of phytoplankton called dinoflagellates. Unlike brown tides, red tides produce toxins that can cause extensive mortality in fish. Only one species occurring in Texas, *Gymnodinium breve*, can cause human health problems. Although not lethal to humans, this organism can cause neurotoxic shellfish poisoning, with abdominal pain, vomiting, diarrhea, vertigo, malaise, and headaches.

Red tides are rare on the Texas coast compared to other areas of the Gulf of Mexico, such as the west coast of Florida. Of the 11 documented red tide blooms along the Texas coast through 1997, only two affected the estuarine waters of the Coastal Bend. The 1986-1987 red tide affected oysters in the bays, and the 1997 bloom affected both oysters and fish. The periodic closure of selected oyster beds by the Texas Department of Health due to detectable levels of red tide suggests that small blooms of red tide may be more common than is generally thought.

Although the ecological and economic impacts of red tides can sometimes be very severe, they appear to have no long term effects on the ecosystem. Fish populations and tourism rebound quickly following the infrequent blooms. Should toxic blooms in Texas increase in frequency and/or severity, however, monitoring activities should be considered

to provide warnings of bloom initiation and transport along the Texas coast.

Freshwater Resources

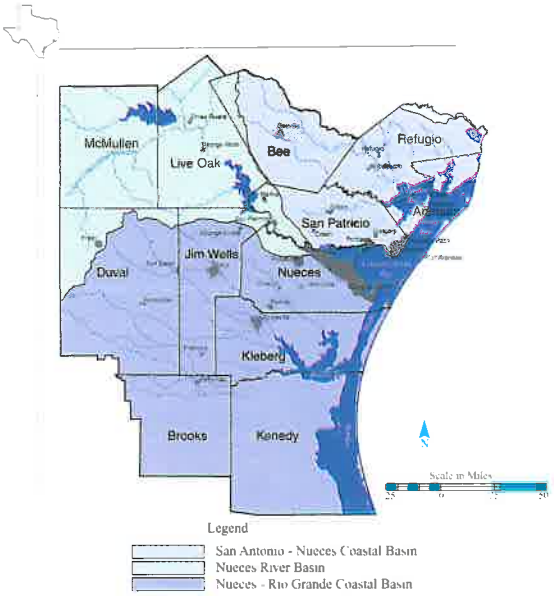
"... the water we drink today also cooled the thirsts of our most ancient ancestors, and even the creatures that came before them. That we can use the same water over and over again is testament to nature's recycling efficiency. The point is that water is a finite resource. For all intents and purposes, no one is making any more of it."

(Texas Shores, Vol. 30, number 4, 1998).

Freshwater was in short supply in South Texas even before people established ranches, towns, railroads, and industries in the semi-arid region. In the face of increasing population and more industry, the scarcity of locally available freshwater means there will always be competing demands on this limited resource.

Freshwater Inflows

Freshwater flowing into the estuaries of the Coastal Bend comes from three major watersheds that cover a total area of about 26,866 square miles. The Nueces River basin is by far the largest drainage area, covering about 16,700 square miles. It extends into the hill country northwest of San Antonio and drains into Nueces Bay, at the head of Corpus Christi Bay. The other two watersheds are essentially coastal, draining local rainfall into the estuaries. In the southern part of the Coastal Bend, the Nueces-Rio Grande basin covers about 7,211 square miles. Streams in this watershed drain into both upper Laguna Madre and into Corpus Christi Bay. In the northern portion of the region, the San Antonio-Nueces coastal basin covers approximately 2,629 square miles and drains primarily into Copano Bay through the Aransas and Mission Rivers.



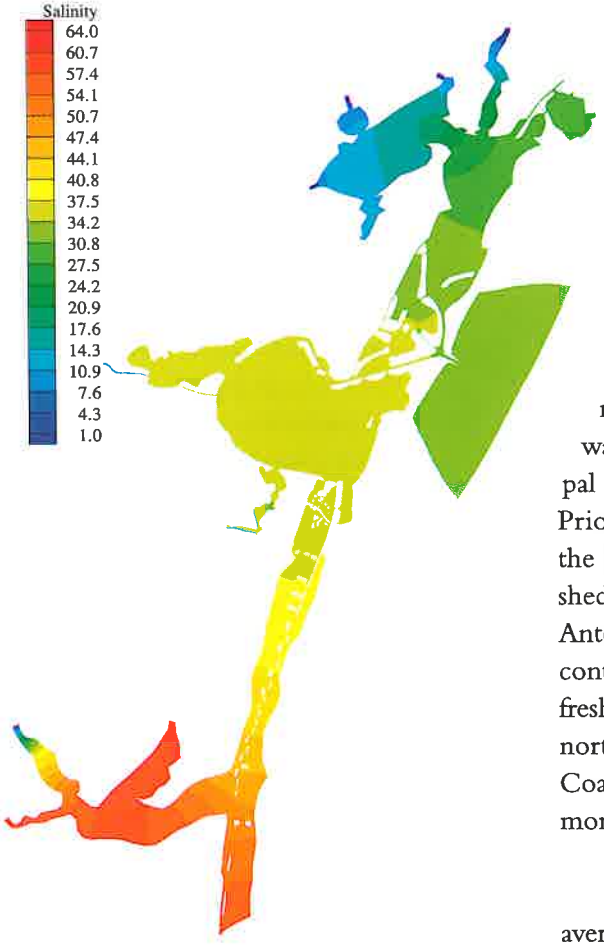
Due to local variation in rainfall patterns, the ability of local soils to absorb rainfall, and the presence of reservoirs, the three watersheds contribute freshwater to the estuaries in disproportion to their size. Although the smallest watershed, the San Antonio-Nueces basin contributes about 53 percent of the total 1.2 million cubic feet of freshwater that enters Coastal Bend estuaries annually. The much larger Nueces River basin currently contributes about 32 percent, and the mid-sized Nueces-Rio Grande watershed contributes only 15 percent.

The total amount of freshwater inflow to Coastal Bend estuaries is relatively low compared to many other coastal areas along the Gulf and Atlantic seaboards. For example, Matagorda Bay, just to the north, receives five times more inflow than is currently received by Corpus Christi Bay. Substantially more rain falls in the northern coastal watershed of the Coastal Bend than in the much larger, but

Freshwater inflows perform three major functions that are essential for sustaining productive estuaries. First, they blend with the Gulf's seawater to provide a range of salt concentrations needed by the living resources that use the estuaries. Second, freshwater inflows bring nutrients essential to the total productivity of estuarine ecosystems. Third, rivers and streams bring in sediments needed to maintain deltas and coastal marshes and avoid the erosion of coastal uplands.

Water that falls to the surface as rain is also returned to the atmosphere through evaporation. Although the high humidity of the Coastal Bend reduces its evaporation rate, evaporation still exceeds precipitation by more than two to one. The result is high salinities in the estuaries, especially toward the southern portion of the Coastal Bend.

Average Summer Salinity (ppt)



relatively arid, interior watershed. In addition, average annual freshwater inflow from the Nueces River has decreased by approximately 53 percent since about 1940. There are two major reservoirs (defined as having a capacity of more than 5,000 acre feet) in the Nueces River basin. Lake Corpus Christi was formed by the construction of Mathis Dam (near the town of Mathis) on the Nueces River in the early 1930s. It was later enlarged by construction of Wesley Seal Dam in 1959. Choke Canyon reservoir, on the Frio River near the town of Three Rivers, was built in 1982.

The retention of water by these two reservoirs in the Nueces basin has had a substantial impact on freshwater inflows to the Corpus Christi estuary. Historical records indicate that the reduction in freshwater inflow is primarily associated with the construction of Choke Canyon reservoir and the diversion of water for agricultural and municipal uses upstream of the reservoir. Prior to the alteration of flows in the Nueces River, the two watersheds (Nueces River basin and San Antonio-Nueces basin) would have contributed similar amounts of freshwater to the estuaries. The northern and central portions of the Coastal Bend would have been more alike than they now are.

In addition to reducing average annual inflows, reservoir construction has also changed the nature of freshwater delivery to the estuaries. Many rivers in the United States, including those in Texas located to the north of the Coastal Bend, have seasonal flows related to spring rains, thaws, and late summer dry periods. However, river flow in south Texas, particularly the Nueces River, is less predictable. Heavy rain may occur at any time during the year, resulting in short, but intense, freshets interspersed with relatively long periods of low river flow. A major tropical cyclone can be the most significant rain event for several years.

Historically, the Coastal Bend estuaries were periodically inundated with a large pulse of freshwater followed by relatively long periods of low inflow. These periodic floods flushed the estuaries, reducing salinities and adding sediments and nutrients from the land, and ultimately rejuvenated the estuarine ecosystem. A significant effect of the water retention capacity of reservoirs in the Nueces River basin has been to minimize the impact of periodic floods, reducing their magnitude and extending the time over which they occur. During times of drought, the reservoirs may virtually eliminate the occasional pulses of freshwater and sediments that would naturally occur and that are necessary for the health of the Coastal Bend estuaries. Reservoirs have reduced river inflow as well as the levels of sediments and nutrients carried by the inflow.

In the Laguna Madre, where freshwater inflow is low and

exchange with the Gulf is minimal, high evaporation rates increase salinities to values exceeding those of seawater. This condition, known as hypersalinity, has a profound effect on the ecology of the system. Prior to the construction of the Gulf Intracoastal Waterway through the Laguna Madre, salinities occasionally exceeded 100 ppt and major fish kills were reported. Waterway construction substantially increased water exchange between the upper Laguna Madre and adjacent bays, and decreased salinities. Fish kills due to hypersalinity are no longer reported from this area.

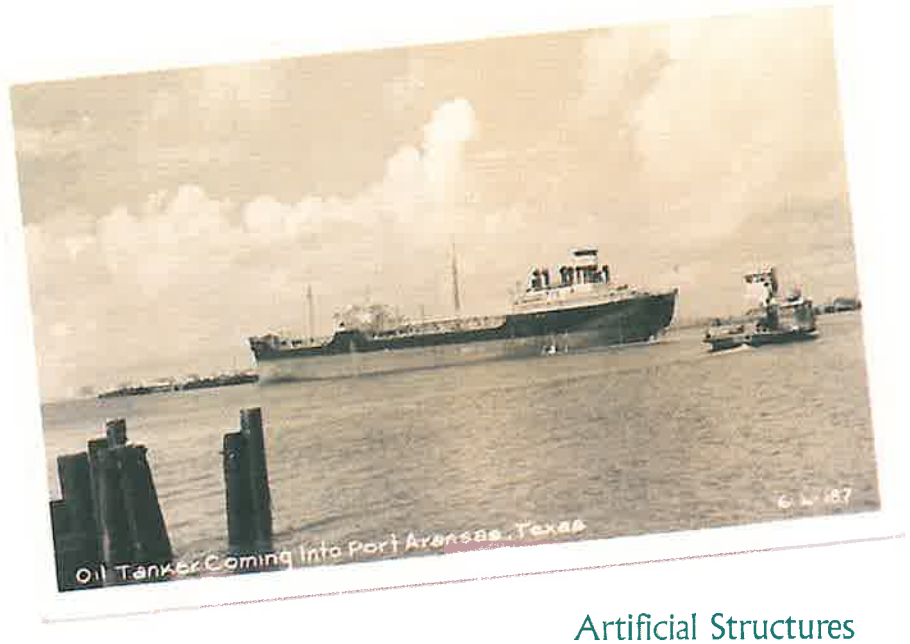
The combination of naturally low inflow rates and high evaporation rates creates relatively long freshwater flow-through times within Coastal Bend estuaries. In fact, it takes four years for water to move through the Aransas and Corpus Christi estuaries. Any unwanted substances, such as toxic pollutants or excess nutrients, that enter these estuaries will not be quickly washed out. Thus, the capacity of our estuaries to assimilate waste materials is relatively low compared to many other estuaries where water residence time is much shorter.

Circulation

Water movement, or circulation, within the estuaries is critically important in the distribution and transportation of waterborne substances, including pollutants, nutrients, or biological components such as plankton or even fish larvae. Certain circulation patterns can also moderate excessive salinities and temperatures. Circulation is driven by several factors including freshwater inflow that enters at a river mouth and pushes through the estuaries, tidal exchanges with the Gulf of Mexico that pulse water in and out of the lower bays, and winds.

Since the Coastal Bend is characterized by low freshwater inflow and a small daily tidal range, winds and other weather events are the major factors driving estuarine circulation. The daily sea breezes in summer and regular frontal passages in winter act to stir water within the estuaries. Water is piled up on the downwind side while the water

Corpus Christi is one of the windiest locations in the United States and this has a major impact on the ecology of the Coastal Bend estuaries. Unlike many other parts of the world, where strong tides or extensive freshwater inflow from rivers are the main forces that move water around, wind-generated currents are often more important in the Coastal Bend. The magnitude of wind driven currents and waves depends on the fetch, or the uninterrupted distance that the wind can blow over water. Both the Corpus Christi and Aransas estuaries offer a long fetch, allowing persistent and relatively strong winds to generate significant waves and currents. This is the main force for moving water, sediments, animals, and pollutants within Coastal Bend estuaries. During episodes of strong winds, waves and currents can change water levels in some areas of the estuaries by as much as 2 to 3 feet in less than a day, causing extensive flooding or drying of tidal flats and low-lying marshes.



level drops on the lee side. These relatively short-term events do not result in water exchange between the estuaries. On the other hand, the occasional strong polar cold fronts experienced by the Coastal Bend do have the strength and duration to produce significant water exchange between the estuaries and the Gulf of Mexico. Such meteorological events reduce some of the problems associated with the very long water residence time.

Another important source of water movement is the seasonal variation in water levels. The Coastal Bend usually experiences high water levels during the spring and fall and low water levels during the winter and summer. These variations in water level are on the order of 2 to 3 feet, almost twice the daily tidal range. More importantly, these water level changes last for weeks or months, and thus contribute to the exchange of water throughout the estuaries. Daily tides, on the other hand, contribute to the exchange of water only in the vicinity of the tidal inlets and act on a much shorter time scale.

Artificial Structures and Estuarine Circulation

Water circulation can be altered significantly by human activities. In the Coastal Bend, several engineering projects may have had substantial impacts on circulation and the mixing of fresh and salt waters in the estuaries. Four examples are the construction of the Corpus Christi Ship Channel, the John F. Kennedy Causeway connecting Padre Island with the mainland, the diversion of water from the Nueces River for municipal and industrial use, and the use of cooling water by two electric generating stations. Using mathematical models, the impacts of each of these projects were examined including the predicted effects of removing each of them.

The single, greatest impact on circulation in Coastal Bend estuaries was caused by construction of the Corpus Christi Ship Channel. Prior to 1907, the area between Port Aransas and Corpus Christi Bay, known as Turtle Cove, was composed of shallow mudflats. There was virtually no water exchange across the flats, and the only substantial connection between Corpus

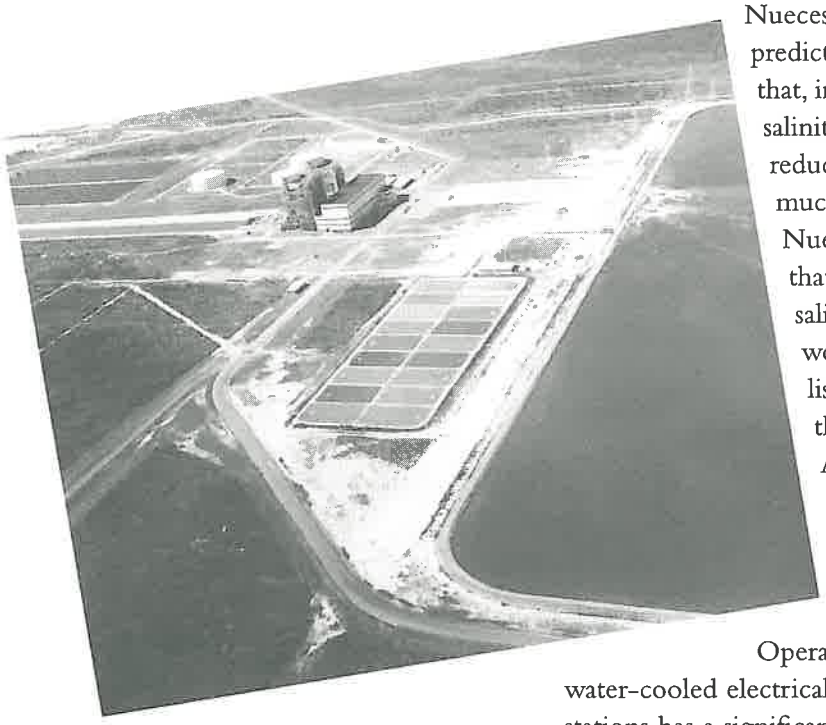
Christi Bay and the Gulf of Mexico was through Corpus Christi Bayou, which connected the Corpus Christi and Aransas estuaries. The Corpus Christi estuary was largely isolated from daily tidal influences, although little is known about the water quality conditions at the time. The first "deep-draft" channel was dredged through the flats in 1925. By 1968, the 45 feet deep by 400 feet wide ship channel provided a major connection between the Corpus Christi estuary and the Gulf. Today, the major site of tidal exchange in the whole region is between the Corpus Christi estuary and the Gulf whereas, historically, it was between the Aransas estuary and the Gulf.

Models predict that this historic alteration in circulation increased water current speeds throughout the Corpus Christi estuary by as much as 50 to 60 percent and increased the mixing of water within the estuary. As a result, it is estimated that salinities in the Corpus Christi and Aransas estuaries were reduced by 1 to 3 ppt in dry periods and were increased by as much as 3 ppt during wet periods. Thus, the channel has acted to moderate extreme salinity conditions.

The JFK Causeway is a landbridge across the northern-most portion of the Laguna Madre. It has been suggested that the causeway restricts the exchange of water between the Laguna Madre and Corpus Christi Bay. Prior to the construction of the causeway, circulation between these two estuaries was relatively poor due to the natural shallowness of Bulkhead Flats, which separated the two. Today, two channels through the causeway, the Gulf Intracoastal Waterway and the Humble Channel, allow water exchange between the Laguna Madre and Corpus Christi Bay. Measurements of currents in these two channels show that, while short-term tidal exchanges are largely blocked by the presence of the causeway, long-term water exchange between the Corpus Christi and Laguna Madre estuaries is not substantially impeded. Removing the causeway would eliminate the blocking effect that results in accumulation of dead seagrass leaves and other debris along the shore. Mathematical models suggest that removing the causeway would also result in a moderate increase in circulation, but essentially no change in salinity, in the immediate vicinity of the causeway. It would not, however, have any substantial effect on circulation or mixing over most of the upper Laguna Madre or Baffin Bay.

Average freshwater inflows through the Aransas-Nueces basin into Copano Bay have not declined over time, remaining at historical levels. Circulation and salinities in this region have not been altered by human activities.

The potential effect of changes to freshwater inflow on circulation within the Coastal Bend estuaries has also been examined. Mathematical models indicate that the impacts of eliminating water withdrawal from the Nueces River for municipal and industrial uses, while leaving all other modifications in place, would be restricted to Nueces Bay. The predicted result is that, in dry years, salinities could be reduced by as much as 2 ppt in Nueces Bay and that a significant salinity gradient would be established across the bay. Alternatively, little effect is seen in wet years.



Operation of two water-cooled electrical generating stations has a significant effect on circulation as each station pumps substantial volumes of water into its plant from one bay and discharges the water into another bay. For example, the Barney Davis plant draws water from the upper Laguna Madre and discharges the water into Oso Bay, where it eventually flows into the Corpus Christi estuary. Virtually all the water drawn through the intake comes from the northern extent of the Laguna Madre and, ultimately, from the Corpus Christi estuary through the JFK Causeway. Essentially no water comes from the main body of the Laguna Madre. Modeling studies indicate that eliminating the intake of water by the Barney Davis power plant would have a localized effect on circulation. Water flow through the causeway would be significantly reduced as almost 50 percent of the flow through the causeway is due to the power plant. Although elimination of the power plant would alter salinity in the vicinity of the JFK Causeway by 1.5 to 2.0 ppt, there would be essentially no effect on the rest of the estuary.

A similar situation is documented with the CP&L Power Plant near Nueces Bay. This plant takes water from the Inner Harbor, which is fed by Corpus Christi Bay, and discharges the water into the central portion of Nueces Bay. Models predict that, without this plant, salinity in the immediate vicinity of the discharge could be reduced by as much as 6 ppt, but essentially no effect would be seen in the other portions of the bay.

If all four of the examined projects were removed, the combined effects would be strongest in Nueces Bay, where average salinities would be reduced by as much as 12 ppt during wet years. Corpus Christi Bay salinities could be as much as 6 ppt lower. At the JFK Causeway, salinities would be more variable than they are now, increasing by about 4 ppt in dry years, but decreasing by as much as 5 ppt in wet years.

"Our bays and estuaries are the lifeblood of the Gulf Coast community, providing billions of dollars in economic activity and countless hours of recreational opportunity"
Former Governor Ann Richards

Human Concerns

The Coastal Bend is home to over 540,000 residents, or about 3 percent of the Texas population. Most people (58%) live in Nueces County and the City of Corpus Christi, along the shores of the Corpus Christi estuary.

A wide variety of economic activities are supported or influenced by the area's bays and estuaries. Many industries or activities, such as the petroleum refining and chemical industries, ship and boat building and repair, and water transport services are located on or near the water because of convenience or cost advantages. These activities may impact the quality of the water and aesthetic value of the estuaries. Other economic activities in the region, including commercial fishing, tourism, and related industries, are more directly connected to the aesthetic and environmental qualities of the estuaries. Together, these estuary-related activities have a total economic impact of $4.1 billion, providing about one-third of the jobs in the Coastal Bend, and generating $1.3 billion in personal income (1995 data). The petroleum and chemical industries have the greatest dollar impact, but tourism and military activities have the greatest job impact.

The recreational appeal of the Coastal Bend is quite obvious. The sparkling waters and sandy beaches provide opportunities for fishing, birdwatching, windsurfing, waterfowl hunting, camping, jet skiing, kayaking and canoeing, swimming, sailing, power boating, and numerous other outdoor, water-related activities. The economic value of each of these activities is not known but fishing, birdwatching, and windsurfing are estimated to contribute $90 million to the local economy. Many other values, such as aesthetic enjoyment and a sense of communication with nature, just can't be quantified.

Coliform bacteria come from sewage that enters the estuaries, from pastureland runoff, and from mammals and birds in the marshes. Vibrio are naturally occurring bacteria in marine and estuarine waters.

Public Health

There are three primary public health issues related to the estuarine environment: the possibility of contracting a disease or illness through eating contaminated foods, the possibility of contracting a disease or illness through physical contact with contaminated waters, and the possibility of injuries during water-related activities.

One of the major risks associated with eating seafood is the ingestion of pathogens, disease-producing organisms such as bacteria and viruses. Coliform bacteria are used as indicators of sewage contamination which could contain human pathogens. Many oyster beds in the Coastal Bend are closed to harvesting because of known or potential contamination.

The amount of reef area closed to harvesting has also increased substantially over the past 35 years. There does not, however, appear to be an increasing trend in coliform bacteria levels found in oysters throughout the Coastal Bend over that period, so the increase in closures is mainly due to changes in regulatory and monitoring procedures. With relatively little commercial harvesting of oysters in the Coastal Bend, most oysters consumed here come from outside the region.

While many types of diseases could be contracted from the consumption of raw oysters, the primary risk to humans is from Vibrio, especially for persons with immune system problems. Although oysters are a potential source of Vibrio infections, it is also possible for infection to result from direct contact with contaminated waters, particularly if an open wound is involved. Thus, all the reported cases of Vibrio infections are not necessarily from oyster consumption. Vibrio infections are very serious in the at-risk population and the death rate is high. Fortunately, the number of reported infections in the Coastal Bend population is quite low despite the opportunities residents and visitors have for both seafood consumption and water contact. An average of only one infection per year is reported in the Coastal Bend.

With the exception of Vibrio bacteria, most disease organisms that pose a potential threat through body contact do not survive in seawater. The Nueces County Health Department monitors local waters for the occurrence of coliform bacteria and has consistently found our estuaries are suitable for swimming and other water sports. Therefore, the threat of contracting an illness through contact with the water appears quite minimal.

Another risk from eating seafood is the ingestion of toxic substances. These substances include metals like zinc and copper, as well as organic compounds like PCB's (polychlorinated biphenyls), pesticides, and herbicides. The highest concentrations of these contaminants are found in some of the sites where runoff from rainfall drains into the estuaries and near wastewater discharge areas.These areas are in the Inner Harbor, in Nueces Bay, and other isolated sites around the Coastal Bend. Toxic concentrations are similar to what has been found in Galveston Bay, except that zinc levels in the Inner Harbor are 10 times the levels found in portions of the Houston Ship Channel. Although information on local contaminant levels has not been collected consistently enough to clearly determine trends, it appears that the concentration of metals is declining with a few exceptions. Several metals may be increasing in Copano Bay, and zinc seems to be increasing in large areas of Corpus Christi Bay and Baffin Bay.

In contrast to the well-publicized problems with toxic contamination of fish and shellfish in other areas of the U. S., there is little indication of a problem in the Coastal Bend.

Water-based recreational activities are popular in the Coastal Bend and these activities result in a substantial percentage of all recreational accidents. Most of the accidents are associated with swimming and fishing. Water-related fatalities number about 8 to 10 each year, about two-thirds from recreational activities and one-third from commercial activities. From a public health standpoint, water-related accidents pose a substantially higher risk than disease associated with either contaminated foods or waters.

A recent compilation of data from the Coastal Bend found that, out of 5,500 tissue samples of aquatic organisms analyzed for toxic substances, less than 100 were above levels considered high enough to be of concern. Only two potential problem areas were found: oysters from Nueces Bay had elevated zinc levels and fish from the Inner Harbor in Corpus Christi Bay had elevated PCB contents. These are not considered significant public health concerns since oyster harvesting is prohibited in Nueces Bay and the Inner Harbor is not an important fishing area.

It appears that public health risk from ingestion of toxic substances in seafood is quite small at the present time.

Bay Debris

Urban and suburban areas throughout much of the U.S. are littered with the solid waste products of modern society. The Coastal Bend is no exception. Although it is not usual to see high concentrations of litter along the remote beach and bay shorelines of the Coastal Bend, bay debris in general is quite visible.

There is little definitive information on the amount or kinds of debris within the Coastal Bend, but it is common to find plastic items such as bags, ropes, six-pack rings, pellets, "peanut" packing material, pails, netting, sheeting, and occasionally medical waste, large appliances, and chemical containers -- some with and some without their contents. The sources, relative amounts, trends in amount or distribution, and impacts of the materials are essentially unknown.

Debris clearly has an aesthetic impact on visitors to the bays and beaches. Numerous cleanup efforts, mostly by volunteers, are organized to remove material from sight.

Studies of debris in other areas of the Gulf of Mexico have shown that there are definite biological impacts. Among these are: ingestion of various items such as plastic bags and foam "peanut" materials by animals that mistake them for food, entanglement of marine mammals and birds in nets and lines, and the covering of bottom sediments and seagrasses with large accumulations of debris.

Maritime Commerce

We make extensive use of the Coastal Bend estuaries for commercial as well as recreational activities. The Port of Corpus Christi is the sixth largest port in the U.S., and its 45 foot draft makes it one of the deepest ports on the Gulf Coast. An increasing trend in vessel traffic (about 80,000 trips from all types of vessels in 1993) and the amount of freight transported (about 77 million tons in 1994) has been documented.

There have been relatively few vessel collisions or major spills in the estuaries. The soft bottoms onshore and offshore are relatively forgiving to ships or barges that run aground. Moreover, spills have generally been concentrated within the Corpus Christi Inner Harbor where it is relatively easy to contain a spill and minimize damage to wildlife and the marine environment. Nevertheless, accidents involving both ships and pipelines have occurred, and incidents in recent years have increased awareness that we must do everything practical to minimize the potential for additional accidents.

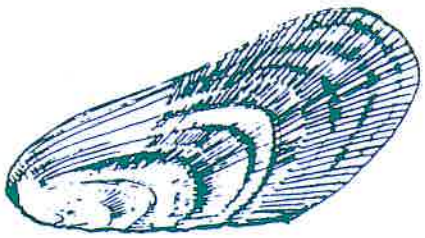
Water And Sediment Quality

Pollutants may enter an estuary from identifiable sources, called "point sources", or from scattered and diffuse sources, called "nonpoint sources". Point sources include municipal and industrial wastewater treatment plants where the amount and kinds of discharges are authorized and monitored by various state and federal agencies. The amounts and kinds of pollutants from these sources are known and their inputs to the estuaries can be estimated.

Nonpoint sources include the runoff from residential and industrial sites, agricultural land, marinas, stormwater outfalls, improperly installed or maintained septic tanks, airborne materials, and other natural and human activities. The kinds and amounts of pollutants from these sources are seldom measured directly and are often not known, but they typically contribute toxic substances, coliform bacteria, oil and grease, nutrients, sediments, or organic material to the estuaries.

Although the estuaries of the Coastal Bend are in pretty good condition overall, there are some trouble areas that need attention. The Inner Harbor stands out among these "hot spots" due to high concentrations of nutrients and heavy metals in the sediments, and organic chemicals such as chlorinated aromatic hydrocarbons (which include PCBs) and polycyclic aromatic hydrocarbons (PAHs) in the sediments.

Zinc concentrations in the sediments of the Inner Harbor are 10 times higher than those documented in the Houston Ship Channel. Elevated concentrations of metals, however, are not confined to the Inner Harbor. Existing information indicates that elevated concentrations of copper, nickel, and



An exotic species, the edible brown mussel, was first observed in the Coastal Bend in 1990, inhabiting the jetties in Port Aransas. The mussel probably arrived from its native South America attached to a ship's hull or in a ship's ballast water. Within four years after its discovery, the mussel had expanded over 1,300 miles to the south of Port Aransas. Although this species is edible, it probably will not support a commercial industry in the Coastal Bend. It requires hard substrate for establishment and growth and this habitat is somewhat limited in the Coastal Bend. The introduction of this mussel may lead to higher maintenance requirements for navigation buoys and water intake systems. It could also displace some native species.

Maintaining good water and sediment quality in the face of an expanding population is important to human health, aquatic life, and the economic vitality of the region.

Water and sediment quality in estuaries is a result of the amount and kinds of different substances that enter the estuaries and the rate at which those substances are diluted or flushed. Many substances, such as copper, are naturally occurring and essential elements for plant or animal growth in small quantities; however, they can be harmful and are considered "pollutants" at abnormally high concentrations. Likewise, nutrients such as nitrogen and phosphorus are essential for plant growth but heavy concentrations of these substances can cause detrimental algal blooms and other negative consequences. High suspended sediment concentrations caused by eroding soil can be harmful to marine life, but a regular inflow of sediment to the estuaries is essential.

zinc occur in sediments throughout Corpus Christi Bay. Compared to concentrations of metals in other regions of the country considered to be "polluted", copper levels throughout the system and zinc in Nueces Bay and the Inner Harbor would probably be considered "heavy pollution". Other "hot spots" of high contaminant levels exist in Baffin Bay, the upper Laguna Madre near Bird Island, La Quinta Channel, Copano Bay, and the Redfish Bay area near Aransas Pass.

The sources of these contaminants are not clear. However, their existence despite a reduction in loads from industrial and municipal discharges over time suggests that these may be historic, but nevertheless persistent, problems. For instance, it has been asserted that there are currently no PCBs entering the estuaries from industrial or municipal discharges, but PCB contamination is still a problem. In Nueces Bay, it is possible that the current pattern of water circulation through the Inner Harbor and into Nueces Bay may contribute to the metal contamination problem.

Runoff from rural land can contribute pollutants to streams and rivers that eventually find their way into bays and estuaries. These pollutants, derived from natural processes and from human activities such as crop production, ranching, and feed lot operations, include nutrients, pesticides, sediments, and organic materials. Information compiled from several studies of local rural runoff shows a wide range in concentrations of several important components, including both nutrients and pesticides. Data collected from the Oso Creek over an 11 year period indicate that

pollutant concentration levels from local agricultural lands are similar to those reported from studies in other parts of the state. Nutrient levels are generally higher than those reported for the Galveston Bay area and pesticide levels are relatively low. Data from recent one year studies of crop land on the King Ranch and Odem Ranch showed much lower nutrient concentrations in crop land runoff than the Oso Creek study. These results suggest that sound agricultural practices can reduce pollutants in agricultural runoff. More data are needed, however, to provide values representative of all conditions. The long-term study of Oso creek shows that runoff and pollutant concentrations are quite variable over time.

Potential pollutants in runoff from urban landscapes include nutrients, bacteria, oil and grease, and various heavy metals. These pollutants are derived from such diverse urban activities as fertilizer and pesticide applications on lawns and landscapes, motor vehicle operation, construction, and operations at commercial and industrial sites. Pollutants in urban runoff from coastal communities present a potential problem in the estuaries because the runoff is concentrated into a relatively small number of storm drains that empty directly into these waters. A survey of pollution concentrations, benthic animal densities, and potential toxicity of sediments around a number of storm water outfalls found that some sites have elevated levels of contaminants that are toxic to sensitive life stages of test organisms, and low species diversity. Two sites had no living organisms at all. The storm drain sites at the Corpus Christi Marina near the L-Head and Cole Park and the Padre Island storm water outfall are specific areas of concern where more comprehensive monitoring should be conducted.

Sediments are a "sink" for pollutants such as metals and pesticides. Sediments accumulate and concentrate pollutants over a long period of time. When activities such as dredging disturb contaminated sediments, the result can be a reintroduction of pollutants into the water.

A better grasp of the sources and accumulations of pollutants can be obtained using models that predict the amount of each pollutant entering the bays from all point source and nonpoint source contributions. A mathematical model created and used by local scientists estimates inputs of nitrogen, phosphorus, oil and grease, copper, zinc, and cadmium into Coastal Bend estuaries. To estimate the contribution of nonpoint source pollutants, the calculations combine freshwater runoff with the pollutant concentrations from various land uses that enter the streams and ditches. The amounts of pollutants that flow into the estuaries can then be predicted. The contribution of pollution from airborne particles is estimated separately from the land contribution.

Preliminary results indicate that the primary source of phosphorus and most metals is from land runoff. About one-half of the nitrogen comes from land runoff but almost one third is derived from the air as a component of rainfall. Therefore, much of the nitrogen and phosphorus and most metals reach the estuaries largely from nonpoint sources. Oil and grease is contributed primarily from point sources and about one-third of the cadmium, copper, and zinc is from these sources. Although 35 percent of the freshwater inflow to Coastal Bend estuaries comes down the Nueces River, the river contributes less than 6 percent of the nitrogen and phosphorus and virtually no metals are delivered by the river.

The passage of the Clean Water Act in 1972, and the subsequent control of point source discharges, has steadily improved water quality in certain, previously impaired areas. Industries and municipalities are investing money and working hard to do their part to achieve clean water. However, historic loads of metals already present in the environment and urban and rural runoff still need our attention. Unlike the situation in numerous other urbanized estuaries around the

world, where communities are struggling to regain clean water standards, part of the challenge faced by the Coastal Bend is to maintain the relatively good water quality we enjoy today.

©


Victoria
Port Lavaca
Port O'Connor
Seadrift
Austwell
Tivoli
Refugio
Goliad
Beeville
George West
Three Rivers
Mathis
Sinton
Taft
Portland
Ingleside
Aransas Pass
Rockport
Fulton
Port Aransas
Corpus Christi
Robstown
Alice
San Diego
Kingsville
Bishop
Riviera
Sarita
Falfurrias
Premont
Encino
Rachal
Armstrong
Norias
Raymondville
Lyford
Edinburg
McAllen
Mission
Pharr
Weslaco
Mercedes
Harlingen
San Benito
Port Isabel
South Padre Island
Reynosa
Rio Bravo
Matamoros
MATAGORDA ISLAND
SAN JOSE ISLAND
PADRE ISLAND NATIONAL SEASHORE
PADRE ISLAND
GULF OF MEXICO
DUVAL
JIM WELLS
NUECES
KLEBERG
KENEDY
BROOKS
WILLACY
HIDALGO
CAMERON
LIVE OAK
BEE
GOLIAD
REFUGIO
SAN PATRICIO
ARANSAS
CALHOUN
KARNES
BRAZOS ISLAND
Boca Chica
Laguna Madre
Intracoastal Waterway

THE STATE OF THE BAY: WHAT CAN YOU DO?

Man and nature work hand in hand. The throwing out of balance of the resources of nature throws out of balance also the lives of men." Franklin Delano Roosevelt

This report has characterized the estuaries of the Coastal Bend as "moderately healthy". Unlike many other estuaries across the nation, our scientific findings do not show major problems. The abundant and diverse habitats of the Coastal Bend provide food and shelter for a variety of living resources. Fishery resources are among the richest in Texas. An astonishing number of bird species live in or migrate through the Coastal Bend. Our bays and estuaries return billions of dollars to the regional economy and provide countless hours of recreational pleasure to residents and visitors alike. The Coastal Bend has, thus far, escaped the well publicized problems with toxic contamination of fish and shellfish experienced in other coastal areas. Relatively good water and sediment quality support healthy living resources as well as the economic vitality of the region.

This "moderately healthy" report, however, should not lull us into complacency. Our economic well being and our high quality of life are dependent on keeping our estuaries healthy. Like most other nearshore areas, the Coastal Bend population is expected to grow significantly over the next 20 to 30 years, placing significant stress on our waters and other natural resources. Other factors somewhat unique to the Coastal Bend, including our semi-arid climate and shallow wind driven bays, will combine to magnify any human impacts. The total amount of freshwater inflow to Coastal Bend estuaries is relatively low compared to many other coastal areas along the Gulf and Atlantic seaboards. In addition, average annual freshwater inflow from the Nueces River has decreased by approximately 53 percent since about 1940.

Low freshwater inflow and high evaporation rates together produce a water residence time of 50 months, quite long relative to other estuaries. This means that our estuaries have a greater tendency to concentrate waterborne substances, including pollutants. Warm water temperatures and high salinities result in oxygen levels that are already near levels likely to cause physiological stress to living resources. There is little capacity to absorb any additional pollutants without harm. We must be careful and vigilant in how our population growth occurs.

More than 50,000 new single family homes are projected to be built in the metropolitan area in the next 30 years. The way in which we grow can destroy or fragment wildlife habitat, overrun farmlands, displace valuable streamside vegetation, threaten wetlands, contribute to air pollution, and increase the runoff of sediments, nutrients, and toxics into our estuaries. Growth will place additional competing demands on our freshwater resources. By the year 2050, water demand for residential and business uses is expected to increase by about 50 percent, while industrial water use is expected to double.

The projected development of Padre and Mustand barrier islands requires careful thought to ensure that the natural shore processes are maintained and that cost effective strategies are in place to minimize coastal erosion and loss of life and property.

THE COASTAL BEND BAYS PLAN

Over 300 citizens of the Coastal Bend have worked for three years to develop a management plan for the estuaries. This plan (the Coastal Bend Bays Plan) describes a series of actions to address the problems confronting the estuaries (as summarized in this document) and protect them for future use and enjoyment. Get involved in this management process by communicating your views to local, state, and federal officials, and by volunteering or contributing resources for appropriate actions. For a copy of the management plan, contact the Coastal Bend Bays & Estuaries Program at 512-980-3420.

Proper planning and decision-making now are essential to address the cumulative impacts of an additional quarter million people in the Coastal Bend and to sustain the balance between the needs of our environment and this human community -- our ultimate quality of life.

In moving from science to prudent action, we must recognize that the problems of coastal ecosystems today are different from the past. Successful solutions in the past relied on traditional approaches such as mandated regulations or end-of-pipe controls. These traditional approaches do not work with the complex problems of pervasive habitat loss or fragmentation, diffuse sources of nonpoint pollution, or freshwater inflow which are often intertwined. Today's problems are also not limited to political boundaries and will often require coordinated, regional approaches.

Our stakeholders and resource managers have looked at the potential problems of the Coastal Bend and have taken a first cut at a regional plan. This Coastal Bend Bays Plan provides the framework for all levels of government -- local, state, and federal -- to join together in a partnership for the Coastal Bend. It funnels the collective wisdom, expertise, and financial resources of the partners to a common focus on the Coastal Bend.

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has." Margaret Mead

Sustaining a healthy environment in the Coastal Bend is also about an informed public making responsible individual decisions. Each of us, in our everyday lives, has the ability to be a steward of the estuaries. For example, we should all use water saving, low flow units in our bathrooms, practice recycling, plant native species of shrubs and grasses, and never disturb nesting birds. We should also:

- Join organizations and participate in programs that work to save the Coastal Bend bays and estuaries.

- Adopt an area within the watershed and help keep it clean and beautiful.

- Teach our relatives and friends about the estuaries and their role in the ecosystem.

- Above all, educate ourselves about the estuaries and their resources and cherish them as the national treasures that they are.

Our lifestyles and livelihoods depend on healthy bays and estuaries. And each of us, in our everyday lives, has the ability to preserve these valuable resources. Become a steward of the Bay!

At Home

- When replacing or installing toilets, use water saving, low flow units.
- Install low flow shower heads. They're inexpensive and they save on hot water heating bills.
- Fix leaky faucets.
- Turn your hot water heater down a few degrees. You will never notice

the difference.

Waste/Recycling

- Recycle all glass, metal cans, aluminum, corrugated cardboard, plastic, and motor oil.
- Bring your own washable canvas or string bags to the grocery store and reuse them for years.
- Avoid purchasing disposable, non-recyclable items -- razors, cameras, and plates, for example.

Yard and Garden

- Plant species of shrubs and grasses that are native to the Coastal Bend environment and require little watering.
- Minimize the use of pesticides, herbicides, insecticides, and fertilizers that may contribute to pollution.
- Choose plants that won't need fertilizer.
- Keep pet waste, leaf litter, grass clippings, and debris out of the street and storm drains. These drains flow directly into our streams, rivers, bays, and estuaries.

Toxics

- Do not pour solvents, paints, and preservatives down drains or toilets.
- Dispose of used oil , paints and solvents at recycling facilities or collection centers.

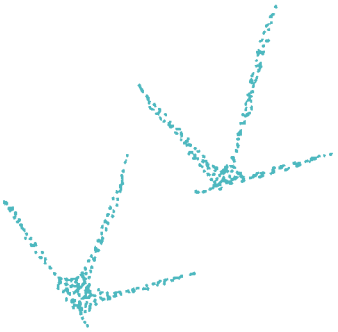
Septic System

- Conduct regular inspection and maintenance activities.
- Call a septic tank service at least every few years.

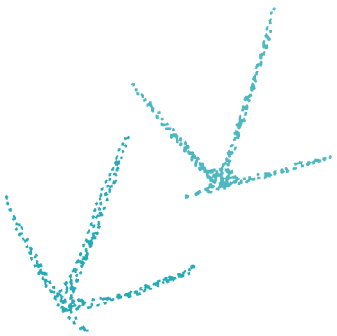
Minesweeper in Texas coastal waters

Boating

- Spread the word that discarded fishing line, plastic bags, or plastic six-pack rings are not only harmful to marine animals but they may also damage boats by tangling props and clogging intakes.
- Empty portable toilets at home. If you have an installed facility aboard, dispose of your waste at the nearest pumpout station.
- Use only antifouling paints available from marinas and boat supply stores.
- Keep a trash receptacle handy for use by every boat passenger.



- Avoid "prop dredging" through seagrasses or other shallow areas. Use marked channels, especially in unfamiliar waters . "Pole" in.



- Stay at least 1,000 feet away from nesting birds islands during the months of February through August to avoid disturbance to nesting colonial waterbirds.

THE STATE OF THE BAY: GLOSSARY

Atmospheric deposition: A complex phenomenon that occurs when emissions of sulfur, nitrogen compounds, and other substances are transformed by chemical processes in the atmosphere and then deposited on earth in either a dry or wet form.

Benthos (benthic): The community of animals living in and on the bottom sediments of a body of water. Occurring at the bottom of a body of water.

Bycatch: The unintended taking of a species while net fishing for another species.

Coliform (bacteria): Widely distributed microorganisms found in the intestinal tract of humans and other animals and in soils. Their presence in water indicates fecal pollution and potentially dangerous contamination by disease-causing microorganisms.

Ecosystem: An ecological community and its environment functioning as a unit in nature.

Fetch: The uninterrupted distance that the wind can blow over water.

Food web: A sequence of organisms, each of which uses the next, lower member of the sequence as a food source.

Habitat: The environment in which an animal or plant can normally be found or normally grows.

Heavy metals: Materials like cadmium, lead, arsenic, mercury, and copper that enter the water from both human and natural sources; in high enough amounts, they may be extremely toxic to biological life and may accumulate from low levels in the water to dangerous levels in the flesh of organisms high in the food web.

Hypersalinity: Having extremely high levels of salinity or salt content.

Loading: The rate at which a pollutant enters a system, such as a water body.

Nonpoint source: An indirect discharge, not from a pipe or other specific source.

Nutrients: Essential chemicals needed by plants or animals for growth. Excessive amounts of nutrients can lead to degradation of water quality by promoting excessive growth, and subsequent decay of plants, especially algae. Some nutrients can be toxic to animals at high concentrations.

PAHs (polycyclic aromatic hydrocarbons): A class of complex organic compounds, some of which are persistent and cause cancer. These compounds are formed from the combustion of organic material and are ubiquitous in the environment. PAHs are commonly formed by forest fires and by the combustion of gasoline and other petroleum products. They often reach the environment through atmospheric deposition and highway runoff.

Pathogen: An agent such as bacteria or viruses that cause disease.

PCBs (polychlorinated biphenyls): A group of manufactured chemicals formerly used for such purposes as insulation in transformers and lubrication in gas pipeline systems. Production, sale, and new use was banned by law in 1977 following passage of the Toxic Substances Control Act. PCBs have a strong tendency to bioaccumulate. They are quite stable, and therefore persist in the environment for long periods of time. They are classified by USEPA as probable human carcinogens.

Photosynthesis: The process by which plants use energy derived from sunlight to make simple carbohydrates from carbon dioxide and water.

Phytoplankton: Free floating aquatic plants, usually algae; an important food source for many animals.

Polychaetes: Marine segmented worms.

Point source: A specific source or point of origin, such as a discharge pipe or outfall.

Primary producers: Plant life (in the water, algae or plankton); the organisms that first convert sunlight into food and are then consumed by higher organisms; the base of the food web.

Subsidence: A geological process whereby the land sinks.

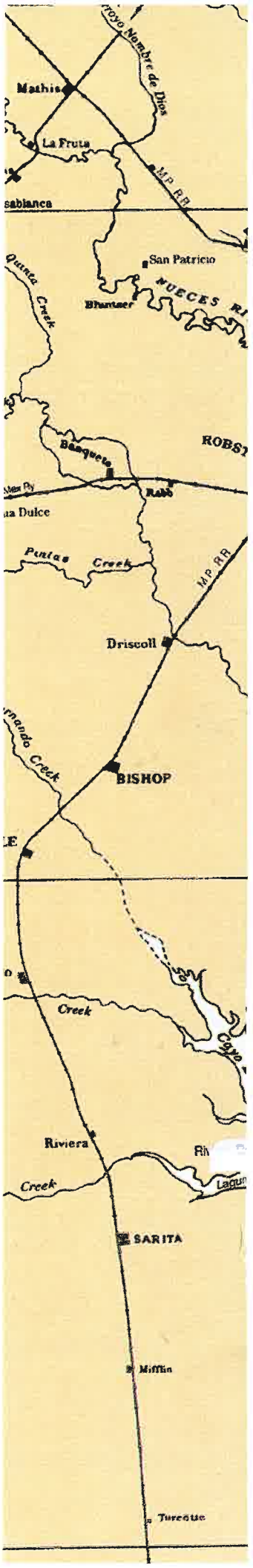
Turbidity: A cloudy condition in water due to suspended silt or organic matter.

Water column: An inclusive term, covering the area that extends from the bottom sediments to the surface, of the water in a lake, estuary, or ocean.

Water quality standards: State regulations that outline permissible levels of individual pollutants in specific bodies of water.

Watershed: The land area that drains into a stream, river, estuary, or other water body; same as drainage area.

Zooplankton: Free-floating aquatic animals ranging in size from microscopic, single-celled organisms to large jellyfish. Zooplankton are an important food source for many types of fish and animals.



COASTAL BEND BAYS & ESTUARIES PROGRAM

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