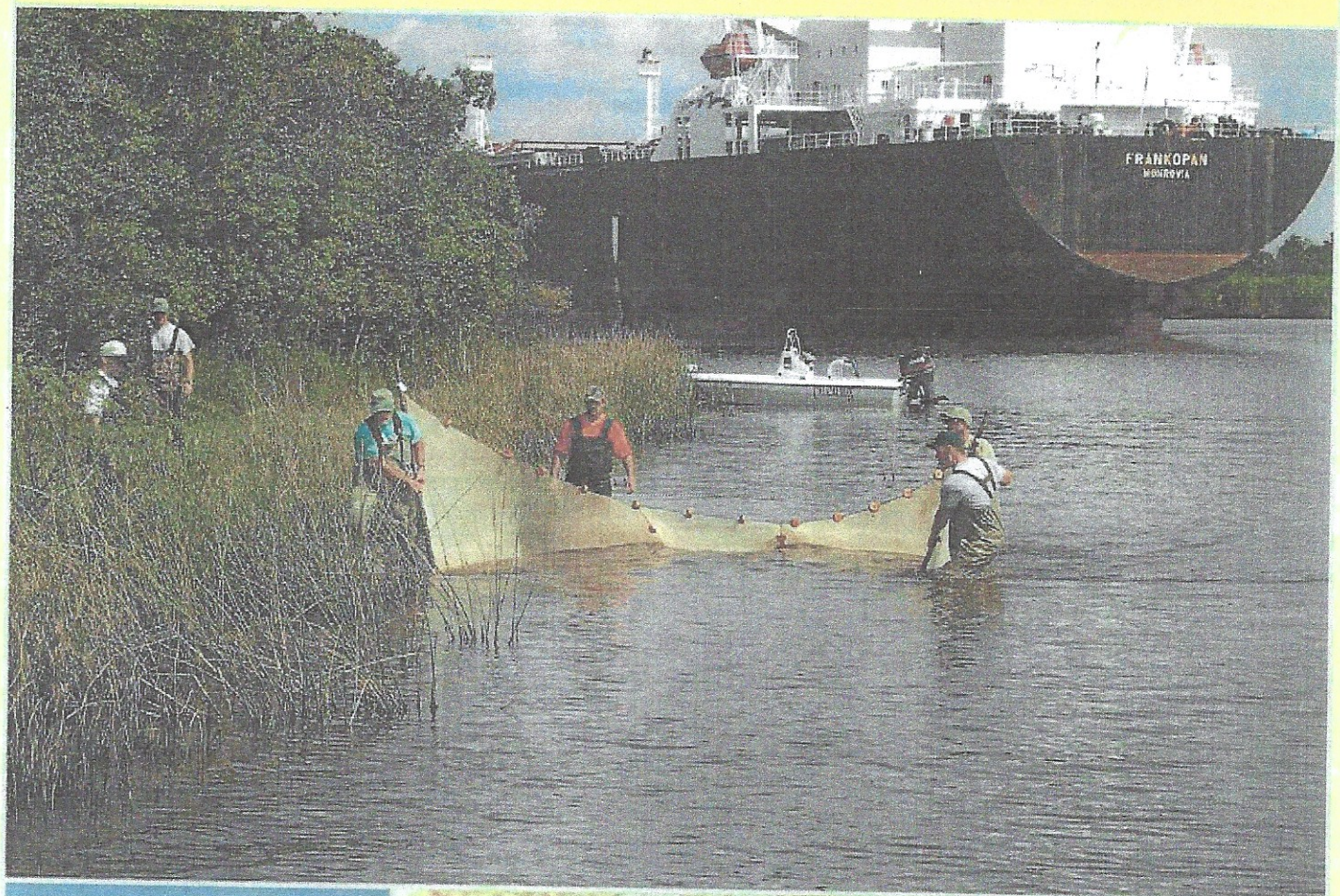
ENVIRONMENTAL MONITORING

LOWER NECHES RIVER



Conducted by **The Academy of Natural Sciences**

Sponsored by **Jefferson County Waterway & Navigation District, Lower Neches Valley Authority, ExxonMobil, and DuPont**

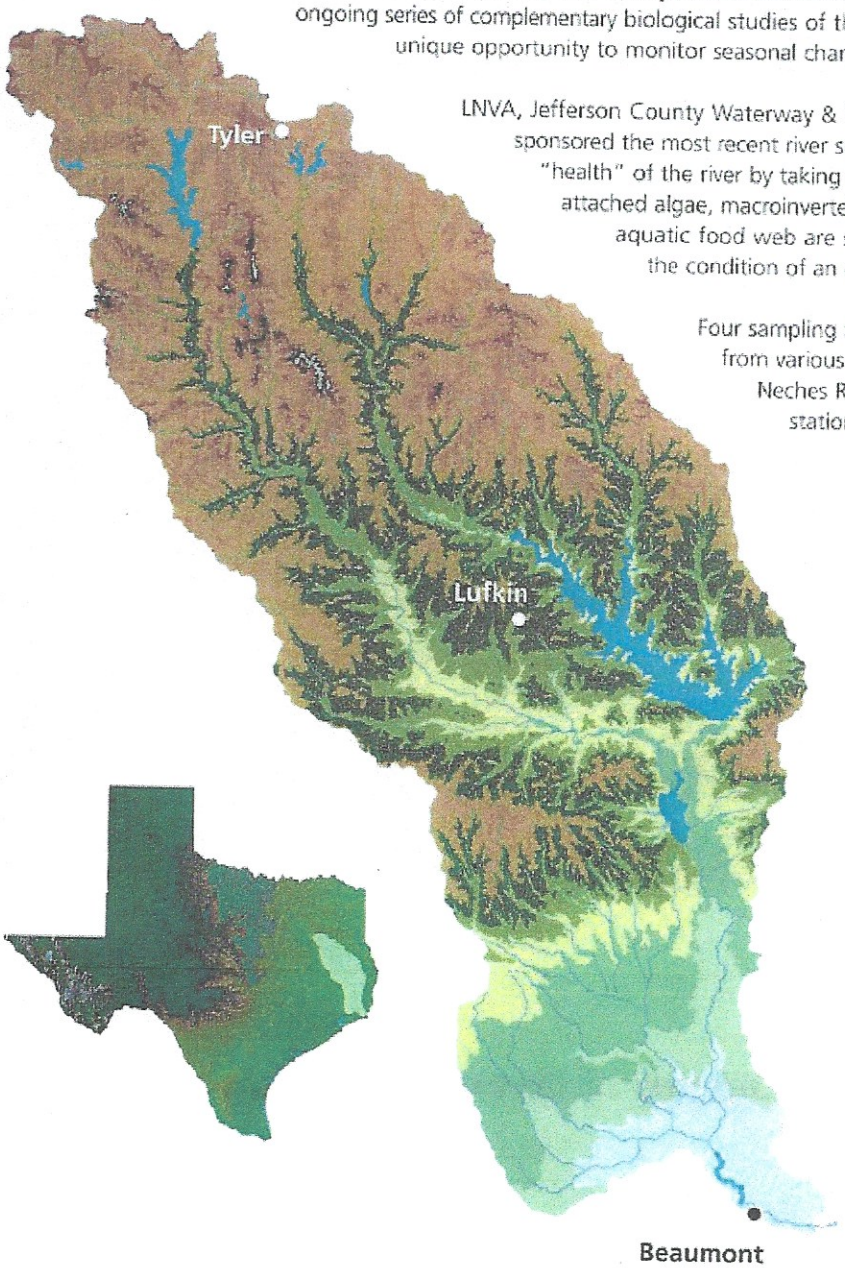
THE NECHES RIVER is more than 400 miles long, extending from near Canton, Texas southeastward to Sabine Lake. Totaling more than 10,000 square miles, the Neches River and its tributaries flow through many miles of picturesque forests including the Big Thicket National Preserve. These heavily wooded areas are one of the sources of naturally occurring organic materials, which, at times, gives the Neches River its distinctive "tea" color. Two large reservoirs, Sam Rayburn and B. A. Steinhagen (Dam "B"), are used to collect and store water as it enters the basin. These reservoirs provide a reliable source of fresh water to the many communities, farms, and industries served by the Lower Neches Valley Authority (LNVA). The Neches River also sustains the region's deepwater ship channel, the Sabine-Neches Waterway, maintained locally by Jefferson County Waterway & Navigation District.

For over 50 years independent academic and scientific institutions have conducted periodic monitoring studies of the lower Neches estuary. During October 2003, the Patrick Center for Environmental Research of The Academy of Natural Sciences completed the sixth in a series of biological and water quality surveys. Previous studies were performed in 1953, 1956, 1960, 1973 and 1996. For over half a century Patrick Center scientists have been using state-of-the-art biological and chemical surveys to assess water quality in a wide range of rivers, lakes and streams around the world.

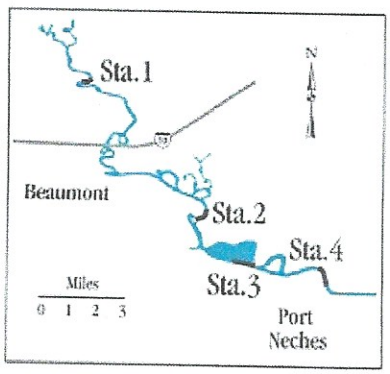
In addition to the Academy river surveys, research scientists from Lamar University have also conducted an ongoing series of complementary biological studies of the Neches River. Lamar's close proximity affords a unique opportunity to monitor seasonal changes in water quality over an extended period of time.

LNVA, Jefferson County Waterway & Navigation District, ExxonMobil and DuPont jointly sponsored the most recent river survey. The study was designed to assess the general "health" of the river by taking water quality measurements, and sampling the attached algae, macroinvertebrate and fish communities. Many levels of the aquatic food web are studied because no single group can reliably indicate the condition of an ecosystem.

Four sampling zones were surveyed: three exposed to influences from various municipal and industrial discharges along the lower Neches River (Stations 2, 3 and 4) and one reference station upriver (Station 1).



(Left): Originating in Van Zandt County and flowing through the woods of east Texas, the Neches River watershed extends over 400 miles, emptying into Sabine Lake. The bold line on the lower portion of the watershed map near Beaumont indicates the Academy's 2003 lower Neches River study area (below).



Above: ***Illustration of the State of Texas courtesy Ray Sterner, Johns Hopkins University Applied Physics Laboratory.*** **Cover: (top): Academy and LNVA staff using a 20' seine net to collect small fish along the shoreline at Station 2. (bottom, left to right): female blue crab guarding her eggs, the spongy mass attached to her abdomen; female least killifish, a rare fish species in the lower Neches; and three large white shrimp.**

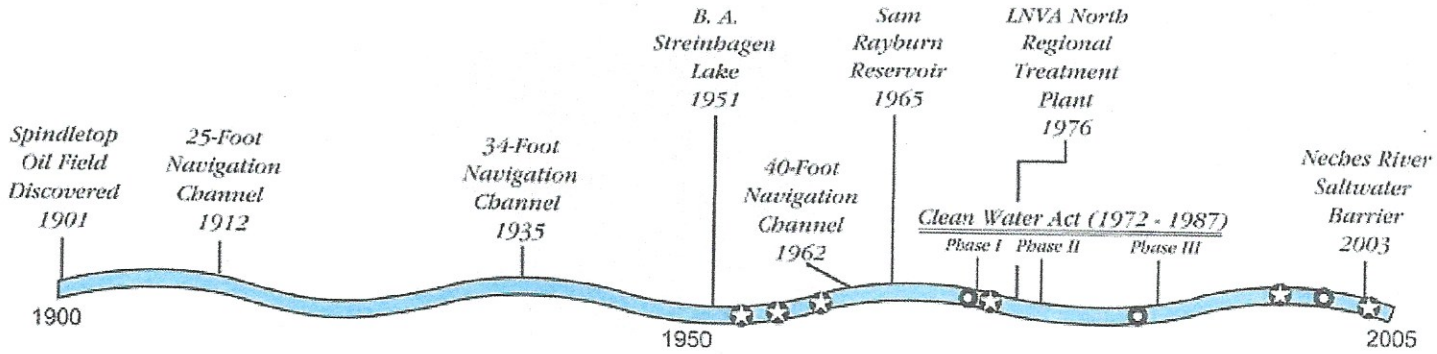


Illustration of key historic milestones in the development of the natural resources within the lower Neches watershed. Comprehensive environmental monitoring studies, conducted since the early 1950s by the Academy and Lamar University, have provided invaluable scientific data for water resource planning and environmental stewardship throughout the region.

Chemistry

Many basic water quality parameters were measured and water samples collected and analyzed for nutrients, certain metals and organic compounds. Salinity generally increased with depth at Stations 2-4, indicating limited water column mixing throughout the downstream portion of the study area. Dissolved oxygen (DO) concentrations throughout the water column were generally favorable at all stations, with the majority exceeding Texas Commission on Environmental Quality (TCEQ) water quality criteria, demonstrating sufficient levels exist for aquatic organisms to live and reproduce. At Stations 2-4, bottom DO values decreased to near zero. Low DO concentrations near the river bed are commonly found in estuarine mixing zones. Microbial activity, in conjunction with limited mixing throughout the water column, can deplete the available DO near the bottom.

Nitrogen, phosphorus and fecal coliform values are commonly used as indicators of human and agricultural activities. All nutrient forms of nitrogen and phosphorus measured were below TCEQ water quality screening levels. Fecal coliform counts however, did exceed the screening level in 10 of 16 samples, most likely due to increased runoff from a large storm event prior to the field sampling. Concentrations of all metals tested were low and below the tidal screening levels, and concentrations of selected organics in the surface water samples were either undetectable or at low levels above the detection limit. Overall, the 2003 lower Neches River chemistry study, as in 1996, revealed stable or slightly improved water quality over the past 20 years.

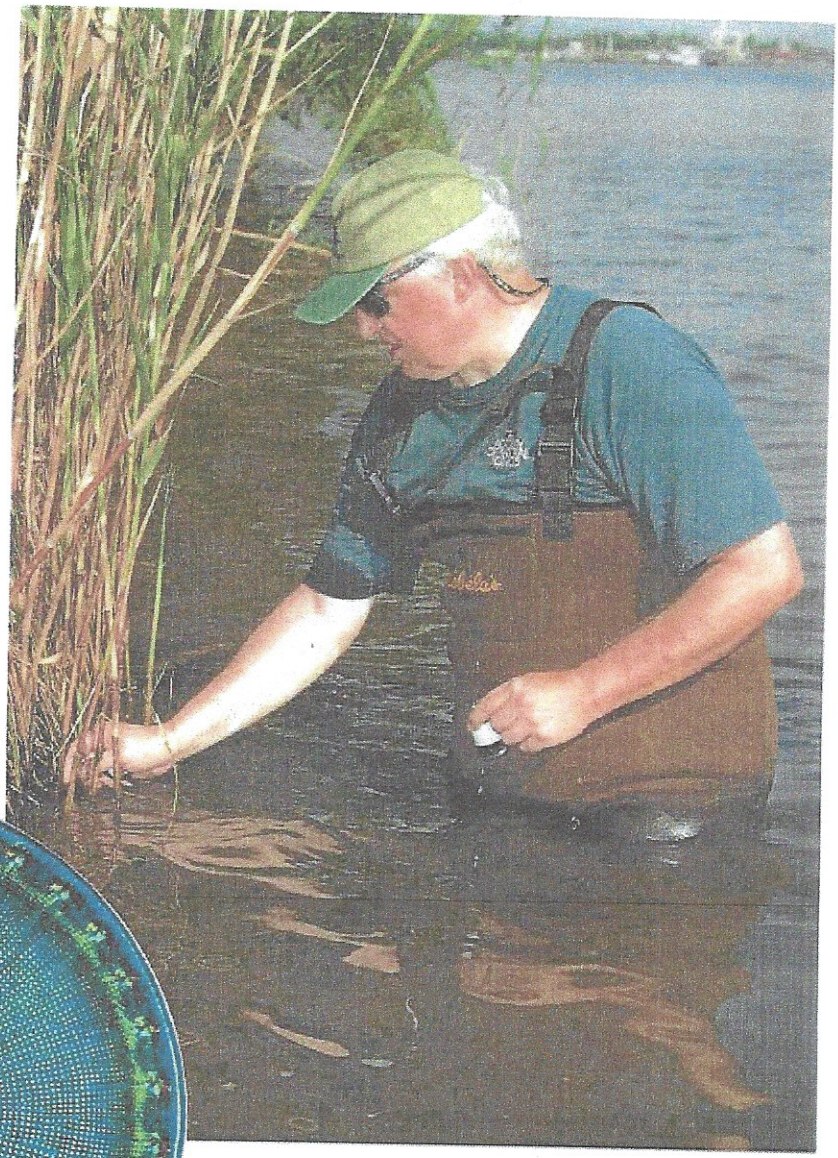
The lower Neches River and estuary contain a wide variety of aquatic habitats, from open water to complex marsh ecosystems. Marsh edges, like that being sampled by Academy field biologist Judy Bouchard (right), contain numerous macroinvertebrates (upper right) and fish that rely on this habitat to live and reproduce. The historic biological surveys conducted by the Academy and Lamar University evaluate many levels of the lower Neches River food web and are a valuable tool used to assess the "health" of the river.
Photos by Tim Nightengale (upper right) and Roger Thomas

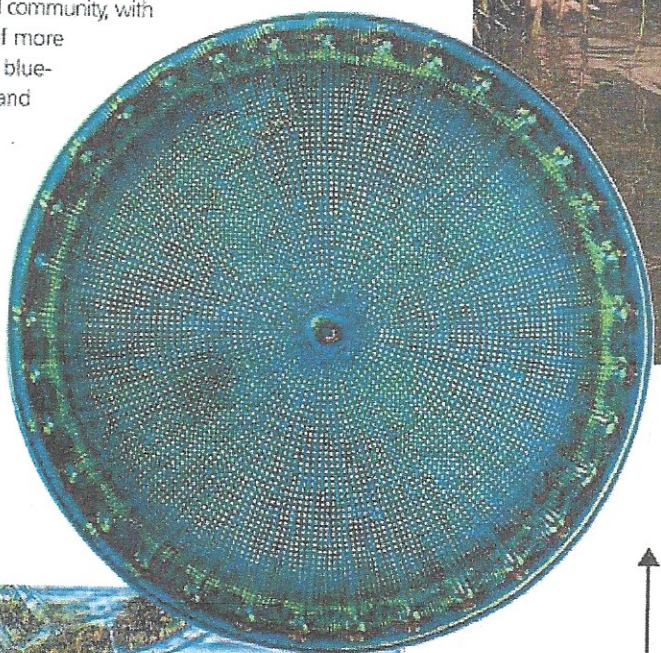
Algae

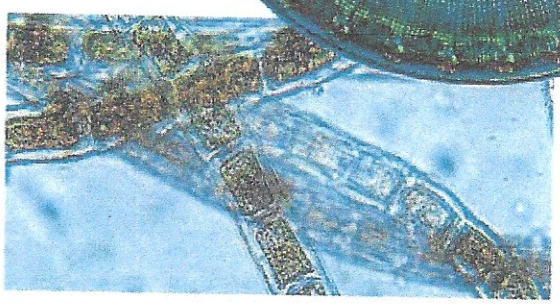
Algae form the base of the aquatic food chain in rivers, lakes and oceans. They use the sun's energy during photosynthesis to grow, providing food and oxygen for many larger organisms. Some forms of algae attach to vegetation and sediments located along the banks of rivers and streams, areas that are constantly exposed to environmental change. Their ability to colonize a wide variety of habitats makes them ideal for monitoring the health of aquatic ecosystems. Algae and diatoms (algae with silica shells) serve as living biological indicators of the ecological condition of streams, lakes and rivers.

Samples of attached algae and diatoms were collected by hand from many different habitats such as mud and sand shorelines, aquatic plants and hard substrates like submerged tree roots. Changes in the numbers of algal species at each site, their relative abundance and community dominance (whether there's a balance of different species or the community is dominated by just a few types), have been used to evaluate water quality on the lower Neches for the past 50 years.

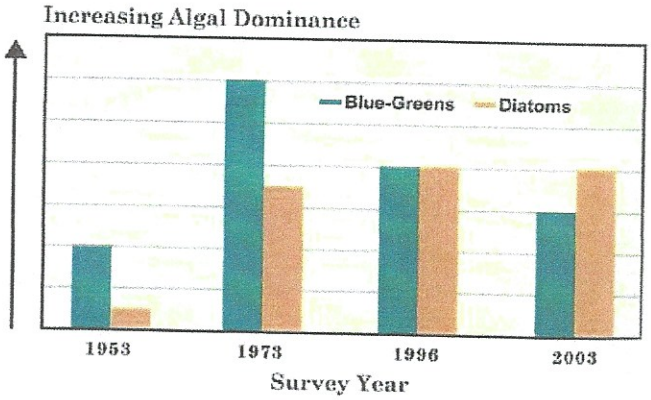
The 2003 results indicate a more balanced algal community, with the presence of more diatoms than blue-green algae, and generally decreased amounts of algae throughout the study area compared with the earlier 1953 and 1973 surveys.







(Upper right): Frank Acker collecting algae along the shoreline at Station 3. Diatoms and algae (middle and lower left), representing some of the smaller forms of life found in the lower Neches, have been used by Academy scientists to evaluate water quality in streams, lakes and rivers around the world. Photos by Frank Acker, Ron Mahoney and Dwain Cox (l. to r.)

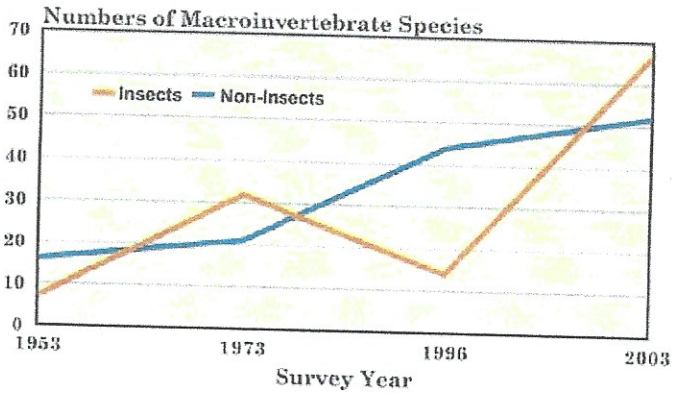


The graph shows the relationship between blue-green algae and diatoms collected at Stations 2-4 during the four lower Neches river surveys. The change in dominance (with an equal or greater proportion of diatoms in 1996 and 2003) reflects the increased water quality throughout the study area since the earlier surveys.

Macroinvertebrates

Macroinvertebrates (shrimp, clams, snails, aquatic insects, etc.) generally provide the link in the aquatic food chain between algae and animals that occupy higher feeding levels, like fish.Their limited mobility, relatively long life spans of some species and responses to a wide range of environmental conditions make them effective in monitoring long-term change. The growth and reproduction of many types are a direct reflection of changes in water quality. Some macroinvertebrates, like shrimp and blue crabs, are also vital to people who live and work along the Texas Gulf Coast. During 2003, nearly 1 million pounds of blue crabs were harvested from the Sabine Lake system, with a dockside value in excess of six hundred thousand dollars.

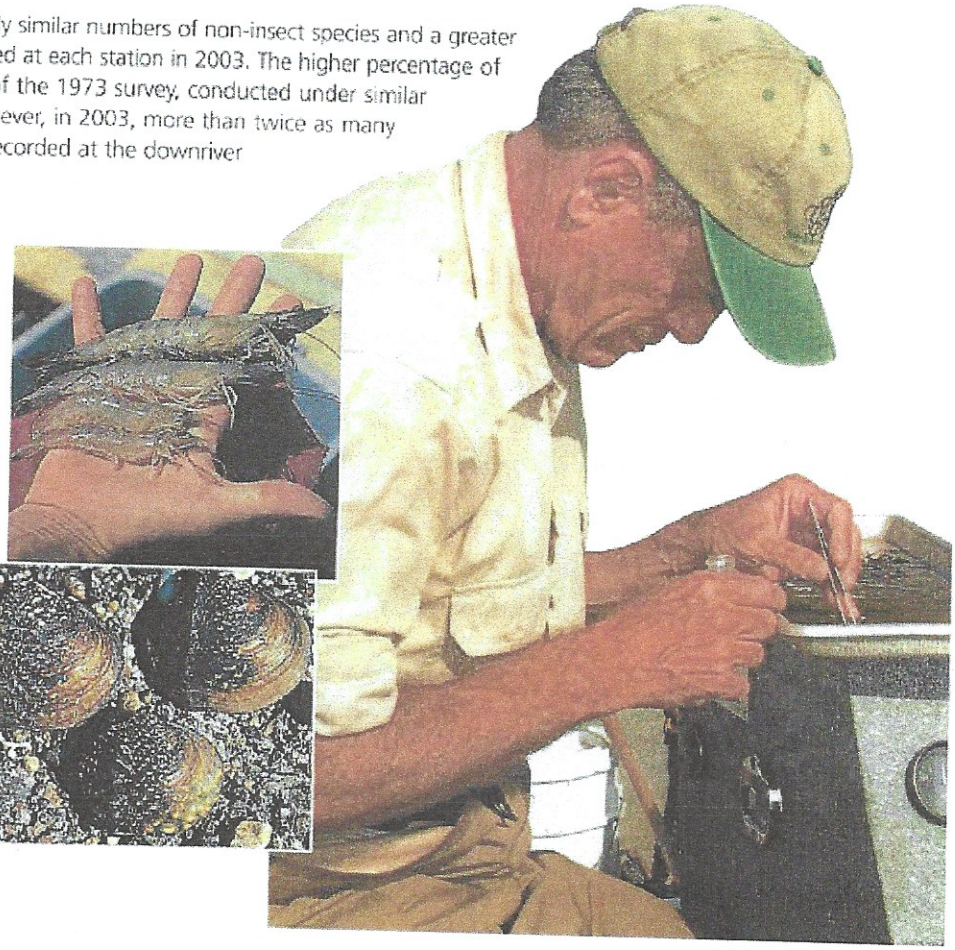
All available habitats were sampled to characterize the macroinvertebrate community within each of the four study sites. Important considerations for the macroinvertebrates included the number and relative abundance of species and their habitats and distributions within the estuary.



The chart illustrates the continued increase in the numbers of insect and non-insect macroinvertebrate species collected over time during the Academy's four comprehensive lower Neches River surveys. As water quality improves, macroinvertebrate diversity increases but the number of insect species can decline when salinities get higher, as during the 1996 survey. Non-insect macroinvertebrates become more numerous as salinities increase, displacing aquatic insects along the river bottom.

Macroinvertebrates can be divided into insect and non-insect groups. Insects dominate freshwater environments and become less diverse when salinity increases, while non-insects are common in both fresh and saline waters. Mollusks (clams, snails, etc.), crustaceans (shrimp, crayfish, etc.) and leeches are the dominant freshwater non-insect macroinvertebrate groups. Polychaete worms (clam worms, etc.) and a very diverse crustacean assemblage (crabs, barnacles, etc.) are more common in saline waters. During surveys with higher annual river discharges (e.g., 1973 and 2003) conditions are favorable for freshwater macroinvertebrates to move further downriver. In drier years (e.g., 1996), because of the greater influence of tidal cycles, conditions favor macroinvertebrates that prefer higher salinities.

Compared to the 1996 survey, roughly similar numbers of non-insect species and a greater number of insect species were collected at each station in 2003. The higher percentage of insects is comparable to the results of the 1973 survey, conducted under similar annual river discharge patterns. However, in 2003, more than twice as many insect and non-insect species were recorded at the downriver Stations 2 through 4, and from all stations combined, than in 1973. These increases in diversity are consistent with the Neches River studies conducted under the direction of Dr. Richard C. Harrel, Lamar University, which showed an improvement in water quality in the lower Neches River between his 1971-1972 and 1999 studies.



Dr. Raymond W. Bouchard sorting macroinvertebrates from Station 3. Shrimp and southern mapleleaf freshwater mussels represent two of the many macroinvertebrate groups common throughout the lower Neches, an area where fresh water flowing downriver eventually mixes with salt water from the Gulf of Mexico. Photos (clockwise from upper right) by Dwain Cox, Dr. Raymond W. Bouchard and Roger L. Thomas

Fish

Fish occupy a wide range of trophic levels, including herbivores (e.g., menhaden which feed on phytoplankton), invertebrate-feeders (including many bottom fishes), and top predators. Many species are recreationally and commercially important, particularly in southeast Texas, where fishing provides family recreation and is an integral part of the local economy.

The Academy fisheries studies document the numbers and kinds of fish that are found in the range of habitats in the study area, including deeper channels, sand beaches and muddy backwaters. The numbers and diversity of fish are key indicators of the amount and quality of food available, accessible habitats and water quality.

Fish were sampled using a trawl and a variety of seine and dip nets. A total of 51 species was collected in 2003 using all techniques, reflecting the salinity gradient throughout the study area, with freshwater species (e.g., some minnows and channel catfish) relatively common at Station 1, and a number of estuarine species (e.g., gulf menhaden, sailfin molly and bay whiff) found only at Station 4. Juveniles of many important commercial and recreational species, including spot, Atlantic croaker, spotted and sand seatrouts, channel and blue catfish, and spotted bass, were also noted.

Academy and LNVA staff removing fish from a 20' seine net (above) and collecting fish at Station 3 using a bottom trawl (left). Photos by Owain Cox

Forty-seven species were recorded from various shallow water habitats by seining, with the main species including bay anchovy, sand seatrout and tidewater silverside. Nine species were collected by trawling, with sand seatrout and bay anchovy being most common. As in the seine samples, the trawl catches reflected increased salinity from Stations 1 through 4, with two species (channel catfish and hogchoker) found only at Station 1 and two species (hardhead catfish and darter goby) caught only at Station 4. Numbers of young fish were trawled both in deep and in relatively shallow waters indicating that the area serves as a nursery ground for a variety of fish species.

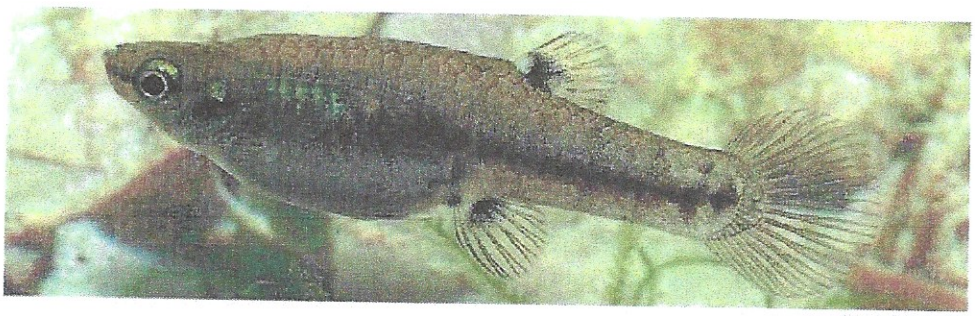


Photo by Roger Thomas

One of the highlights of the 2003 fisheries survey was the collection of a least killifish at Station 3. Least killifish (left) grow to approximately 11/4 inches and are common in the Gulf Coastal Plain from southern North Carolina to Louisiana, but rare along the western Gulf coast. The collection in the Neches River may represent the westernmost record for the species.

The number of species recorded during the 2003 fisheries survey equaled the 1996 study. The number at each station was greater in 2003 than in 1973 at all stations: Station 1 (32 vs. 22 species), Station 2 (20 vs.12), Station 3 (19 vs.12), and Station 4 (18 vs.16) with an increase in total numbers of species at all stations (51 vs. 33 species).

The 2003 lower Neches River fish collections reflect a mixture of freshwater and estuarine species found throughout the inland and coastal waters of the northwestern region of the Gulf of Mexico. The varied wetlands and marsh habitats within the lower Neches River basin provide essential nursery areas for numerous fish species. The fish fauna recorded during the most recent survey indicates that the existing water quality and habitat diversity support a productive and substantial fish community.

Fish Species	Survey Years 1953	1956*	1960*	1973	1996	2003
Longnose Gar	-	X	-	-	-	-
Spotted Gar	X	X	X	X	-	X
Alligator Gar	-	-	t	-	-	-
American Eel	X	-	-	-	-	-
Speckled Worm Eel	X	-	X	-	X	-
Gulf Menhaden	-	-	-	X	X	X
Skipjack Herring	X	-	-	-	-	-
Shad (2 species)	X	X	X	X	X	X
Smallmouth Buffalo	X	-	-	-	-	-
Black Buffalo	X	-	-	-	-	-
Bay Anchovy	-	-	X	X	X	X
Carp	X	-	-	-	-	-
Spotted Sucker	-	-	-	X	-	-
Catfish species	-	-	X	-	-	-
Blue Catfish	X	-	-	X	X	X
Black Bullhead	-	-	-	-	-	X
Channel Catfish	X	-	-	X	X	X
Flathead Catfish	X	-	-	-	-	-
Hardhead Catfish	-	-	-	-	X	X
Pirate Perch	-	-	-	-	-	X
Sheepshead Minnow	X	X	X	X	X	X
Western Mosquitofish	X	X	X	X	X	X
Sailfin Molly	X	X	X	X	X	X
Gulf Pipefish	-	-	-	-	X	X
Searobin species	-	-	-	-	X	-
Warmouth	X	-	X	-	-	-
Bluegill	X	-	X	X	X	X
Longear Sunfish	X	-	-	X	X	X
Redear Sunfish	X	-	-	X	X	X
Spotted/Redspotted Sunfish	X	-	-	-	-	X
Banded Pygmy Sunfish	-	-	-	-	-	X
Sunfish species	-	-	-	-	X	-
Spotted Bass	X	-	-	-	X	X
Largemouth Bass	X	-	-	X	-	-
White Crappie	X	-	-	-	-	X
Black Crappie	X	-	-	-	X	X
Silver Jenny	-	-	-	-	-	X
Flagfin Mojarra	-	X	-	-	-	-
Lookdown	-	-	-	-	X	-
Spotfin Mojarra	-	-	-	-	X	-
Sheepshead	-	-	-	-	X	X
Pinfish	-	-	-	X	X	-
Freshwater Drum	X	-	-	-	X	X
Sand/Silver Seatrout	-	-	-	-	X	X
Spotted Seatrout	-	-	-	-	X	X
Spot	-	-	-	X	X	X
Atlantic Croaker	-	-	X	X	X	X
Red Drum	-	-	-	X	X	-
Star Drum	-	-	-	-	X	X
Atlantic Spadefish	-	-	-	-	X	-
Striped/White Mullet	X	X	X	X	X	X
Fat Sleeper	-	X	X	-	X	X
Bay Whiff	-	-	-	X	X	X
Lined Sole	-	-	-	-	X	-
Hogchoker	-	-	-	-	X	X
Blackcheek Tonguefish	-	-	-	-	X	-
Minnow/Shiner species	X	-	X	X	X	X
Topminnows, Killifish	X	X	X	X	X	X
Silverside species	X	X	X	X	X	X
Darter species	X	-	-	X	-	X
Goby species	X	X	X	-	X	X
Number of Species	38	12	24	33	51	51

The number of species recorded during the 2003 fisheries survey equaled the 1996 study and the number at each station was greater in 2003 than in 1973 at all stations.
Due to the numbers of species recorded, the table has been condensed. For example, there is more than one species in the groups Minnow/Shiner through Goby (* Indicates cursory surveys. t = tentative identification). The background drawings represent groups of fish found in the Neches River. Predators (upper), like the spotted bass, feed upon smaller fish and macroinvertebrates. Filter-feeders, such as the schooling gizzard shad, eat small animals as they swim through the water. Longear sunfish and channel catfish (lower) scour the river bottom looking for food.

Dr. Richard C. Harrel, a Fellow of the Texas Academy of Science, has been a professor of Biology at Lamar University since 1966. He has studied macro-invertebrates in Texas and Oklahoma streams and rivers for over 40 years.

Locally, Dr. Harrel has designed, completed and published several water quality studies of the lower Neches River. Using a variety of environmental indicators, he has documented the response of aquatic habitats to changing environmental conditions.

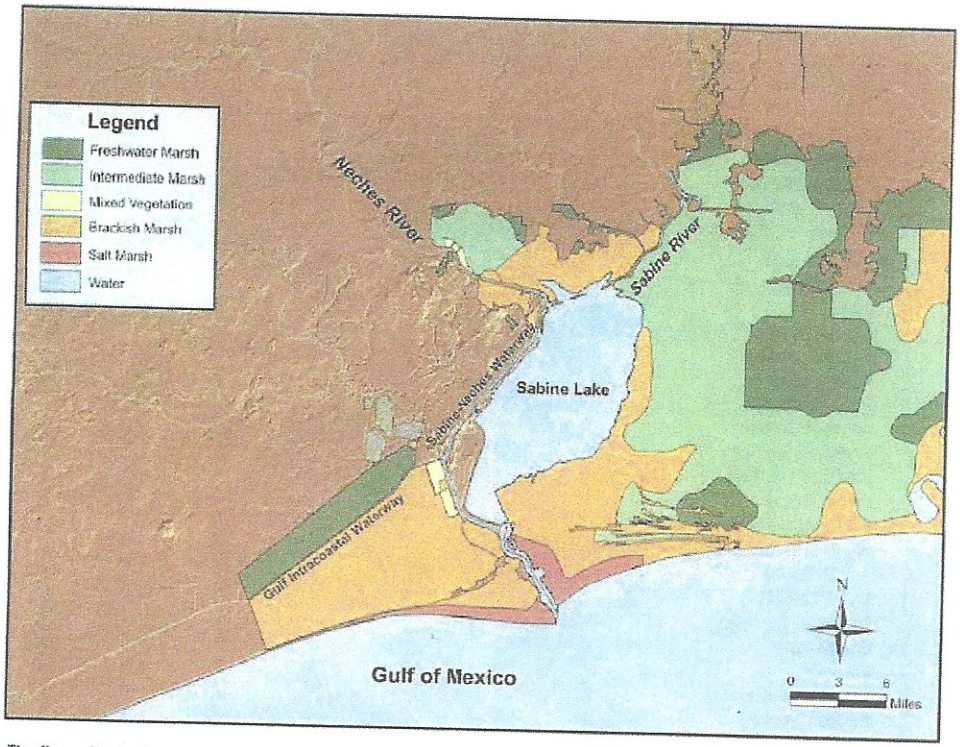
Dr. Harrel's 1971-1972, 1984-1985 and 1999 studies on changes in the numbers and diversity of organisms living on the river bottom showed that the Neches River water quality had improved due, in part, to several local pollution abatement projects. Dr. Harrel has also used the estuarine clam *Rangia cuneata* to monitor intermittent and low level contaminants that are difficult to detect by standard water quality analyses. Because of their long life spans, need to filter particulates for food, ability to bioaccumulate contaminants and sedentary lifestyle, *Rangia* have proven to be effective water quality monitoring organisms.

Summary

Biological surveys conducted by The Academy of Natural Sciences over the past 50 years have measured and evaluated the many forms of estuarine life in the lower Neches River. These environmental monitoring studies provide a valuable reference that government, business and the community can use when planning future development within the basin.

Today, the lower Neches estuary supports diverse algal, macroinvertebrate and fish populations that are generally indicative of a healthy aquatic environment. The results of the Academy's historic studies demonstrate how long-term regional planning and collaborative partnerships can play an important role in improving water quality. In the future, the health of the lower Neches will depend upon preserving and enhancing biological diversity throughout the estuary.

A reliable supply of fresh water is an important key to the well being of all forms of life found within the lower Neches River basin. Wise management of the watershed will ensure the availability of this valuable resource for future generations.



The figure illustrates the complex nature of the lower Neches watershed and Sabine-Neches estuary. The variety of marsh habitats (from freshwater to salt) are critical to the survival of countless plants and animals. The preservation of marsh and wetland nursery habitats, like the one below, is key to sustaining a healthy environment along the Gulf Coast. Illustration modified from original design by TurnerCollie&Braden Inc. for LNVA and Sabine River Authority.

Photo by Roger Thomas

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