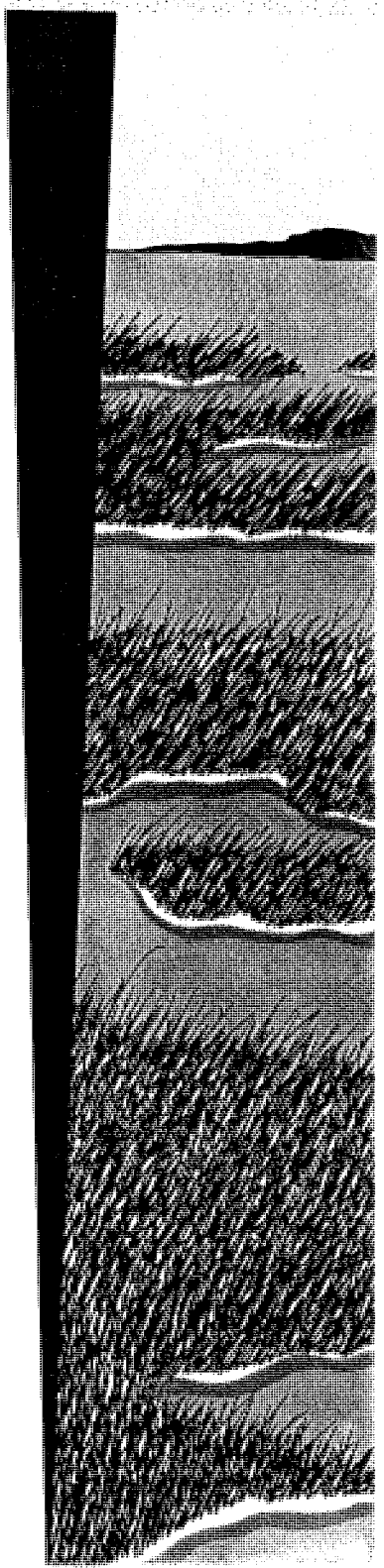
ALBEMARLE-PAMLICO

Albemarle-Pamlico Estuarine System



The Albemarle-Pamlico Estuarine System

A summary of the preliminary status and trends report of the Albemarle-Pamlico Estuarine Study

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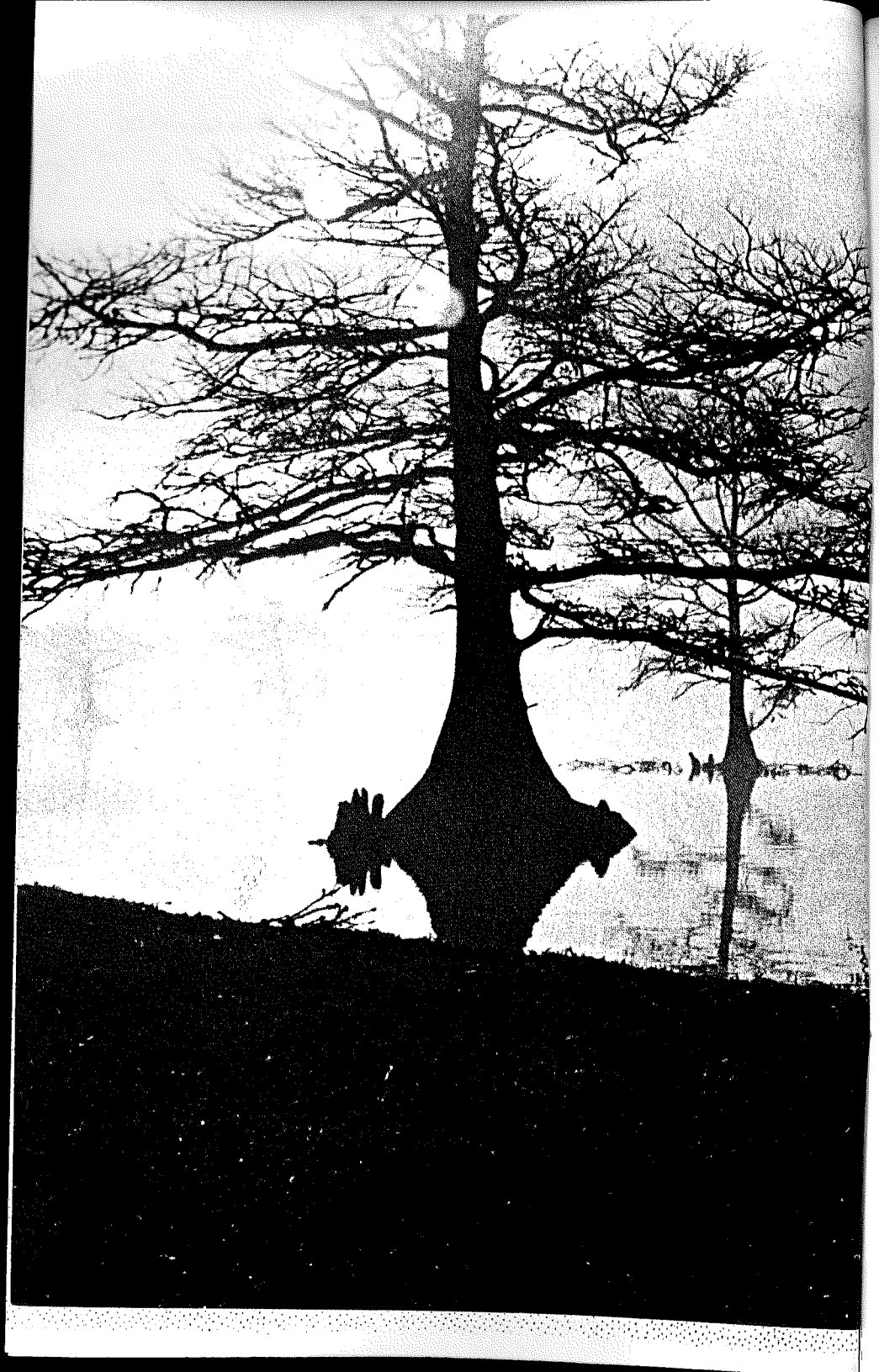
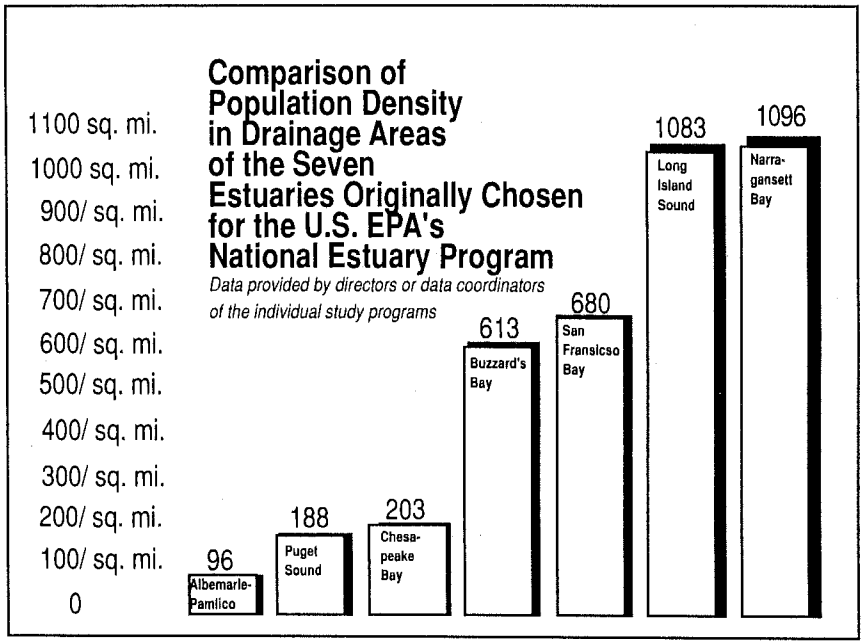


Introduction

In April 1987, the Congressional Office of Technology Assessment issued a report titled Wastes in Marine Environments, which asserted that, in spite of a suite of laws enacted during the 1970s to protect them, many of the nation's critical coastal ecosystems are in serious decline. The report turned public attention once again to threatened estuarine systems. The public was reminded of places like Chesapeake Bay, Maryland; Narragansett Bay, Rhode Island; Buzzards Bay, Massachusetts; Long Island Sound, New York; Puget Sound, Washington; and San Francisco Bay, California—places where decades of population concentration and industrial development have resulted in toxic contamination of sediments, pathogenic contamination of shellfish beds, and dramatic declines in living resources.

But, in 1987, the national public also heard names of some threatened estuarine systems for the first time. One of them was the Albemarle-Pamlico Estuarine System in North Carolina. The third largest estuarine complex in North America and a key nursery area for East Coast fisheries, the Albemarle-Pamlico System had just been designated an estuary of national significance and selected to be studied, along with those just mentioned, under the Environmental Protection Agency's National Estuary Program.



Since that time, the Albemarle-Pamlico System has received a great deal of attention from the national as well as the local press. This attention, plus continuing publicity about the decline of neighboring Chesapeake Bay and inclusion of the Albemarle-Pamlico System in a study with some of the most troubled estuaries in the world have served to confirm the fears of many long-time residents of North Carolina coastal areas. Having witnessed dramatic changes in their own communities and towns, many of these residents have come to believe that—like Buzzard's Bay and the Chesapeake Bay—the Albemarle-Pamlico Estuarine System is in severe decline. Still, many coastal residents welcome the economic growth that development and diversification have brought to the area, even as they wonder about the changes they see.

The Changes We See

People who grew up near the rivers and estuaries see striking changes in the environment. In places along the river banks submerged grasses once grew in beds so thick it was necessary to cut a boat path in order to go and come between the open river and shore. Today, the grasses are gone and with them the young fish and shellfish that were hidden and nurtured among them. Today, instead of undulating beds of grasses, those who live along the river banks see bare sediment—when they can see the river bottom at all. More often, the river waters are turbid and dirty looking. People who observe these changes have strong reasons for concluding that the water of the rivers and estuaries is not as good as it once was and that it's not supporting the plants and fish that used to flourish in it.

Long-time residents have seen even more intrusive change all around them. In some places they have seen vast swamp areas they knew to be inhabited by snakes and bears and other wildlife cleared, drained by networks of ditches, and planted in extensive fields of soybeans, wheat, and corn. In other places, they have seen shopping centers and condominium complexes spring up near fragile marshlands, which they knew to be nursery areas for fish and shellfish. As they've watched these habitats disappear or become infringed upon, they've concluded there's no way that the species which depend upon them will remain unaffected.

Coastal residents have also seen their favorite shellfishing areas disappear or have seen signs go up forbidding shellfishing in these areas because of contamination by human waste. They look around and see parking lots, motels, houses, and businesses crowded upon these sensitive areas, and the source of contamination seems clear.

Men and women who fish North Carolina's coastal rivers and estuaries for a living have seen their catches decline, particularly catches of the kinds of fish that bring good market prices. They see a lot of fish and crabs with skin and shell diseases, and they know these fish and crabs can't be sold for human consumption. From time to time these fisherpeople see hundreds, sometimes thousands, of dead fish floating in the rivers and estuaries. Those who spread their nets in the rivers also know that from time to time they will gather—not fish—but a harvest of algae that tangles the nets and creates a stink as it rots in the sun. They conclude that the fishery resource and the water that it depends on are declining, and they fear that they and their children will have to abandon fishing as a way of life.

These coastal North Carolinians are not alone in their fears for the estuarine environment. Publicity about the problems of the estuaries and evidence of change have reached citizens across the state, and a widespread perception has emerged that the Albemarle and Pamlico estuaries face an environmental crisis.

However, some residents of the Albemarle-Pamlico area, perceive a different crisis because they view changes in the estuarine areas in a different way. They point out that there is a need for balance—balance between development and preservation.

To those whose livelihood depends on tourism, a hotel near a salt marsh is 30 rooms with a beautiful view, and a restaurant on the water has an attractive atmosphere. To a farmer, a broad, flat field is one where soybean or corn production can be highly mechanized for maximum efficiency. To people who visit the area, hotels, restaurants, and marinas are necessary accommodations. And, to those whose favorite pastime is fishing, the rivers and estuaries are bountiful resources available to everyone.

How people view changes in the Albemarle-Pamlico Estuarine System obviously depends upon how they personally want to use the resources. Increasingly, conflict is arising among uses of the estuarine resources—and among users.

Boaters may think a locale is perfect for a marina because it provides a quiet haven and is accessible. But people who take shellfish from the location will think otherwise because raw sewage is often discharged by boaters and because marine fuels and other materials used to service boats can pollute the water and sediment.

A recreational fisherman may think it's wonderful to be able to pull a shrimp trawl in the sound and take home a few dozen pounds of shrimp for the freezer. A commercial shrimper may think it's not so wonderful when thousands of recreational fishermen are doing the same thing and competing for the available resources. A soybean farmer may think a small stream flowing by his field provides an excellent drainageway for ditches that lower the water table in his field and keep his crops from being drowned. Fishermen who know the stream is a primary fishery nursery area that can be damaged by freshwater inflow disagree.

Commercial clammers may think that dislodging clams from seagrass beds with the force of a vessel's propeller is an effective harvesting method. People who know the ecological value of submerged grasses and the harm that "clam kicking" does them think otherwise.

The use conflicts even extend far upstream from the immediate estuarine area. Residents of inland towns and cities see streams that pass through their localities as water supply and waste disposal resources. When these streams reach the coast, they are expected to be resources for fish propagation and other uses that they may no longer be able to support.

Because the estuarine system is viewed as a resource to be used in virtually any way humans choose, its own inherent value is ignored and its ecological integrity is threatened. Therefore, there are two sides to the problem that the State and the people of North Carolina must address in the Albemarle-Pamlico Estuarine System. One side involves preserving the ecological integrity of the natural system; the other involves resolving human conflicts over uses of the resource.

The Albemarle/Pamlico Estuarine Study

Finding out just how serious environmental problems in North Carolina's estuaries are and how the estuaries can be protected at the same time they are being used by more and more people is the purpose of the cooperative study that was announced in 1987 by the State of North Carolina and the U.S. Environmental Protection Agency. This program, called the Albemarle-Pamlico Estuarine Study, is part of what is now the N.C. Department of Environment, Health and Natural Resources.

The study efforts are focused and guided by committees composed of people with knowledge about all aspects of environmental science and relevant environmental laws as well as concerned citizens. When the study began, these committees identified the events and changes in the estuarine environment that worry coastal residents and the people who work in federal and state environmental, wildlife, and fisheries agencies in North Carolina. For more than two years, scientists funded by the Albemarle-Pamlico Estuarine Study and other federal and state agencies as well have focused attention on these problems. The knowledge they have acquired supplements information generated by more than 25 years of research conducted by North Carolina institutions.

Recently, a great many of the scientists who have been involved in estuarine-related studies agreed to serve as members of a workgroup to collect and summarize relevant information about environmental conditions in the Albemarle and Pamlico Estuary Systems for the Albemarle-Pamlico Estuarine Study program.

The Purpose of this Report

This group of scientists was asked to describe the problems that exist as accurately and completely as possible, to identify what factors are probably causing these problems, and to recommend what additional information must be gathered in order to make final and definite judgments about the causes of environmental changes in the estuaries. The workgroup was asked to write a detailed "technical report" on its findings and recommendations and a summary report that would describe the findings and recommendations in language everyone can understand.

It must be emphasized that this workgroup was not asked to make any recommendations about what should be done to solve the problems. Next year, after additional information has been gathered and synthesized, another group composed of state environmental officials and experts on environmental law and other related fields will be asked to make those recommendations.

This summary then, is about the search for probable causes of each of the environmental problems described above, but, just as important, is also about making sure we understand the problems.

Background: The Albemarle/Pamlico Estuarine System Dynamics

Any attempt to understand the problems of the Albemarle-Pamlico Estuarine System must be based on an understanding of the dynamics of the system, that is the continuous movement and change (flux) within the system and the forces that cause the movement.

The system being studied is made up of the Albemarle Sound (including Currituck and Croatan sounds) with its many tributaries and fringing swamps and marshes and the Pamlico Sound (including Core, Roanoke, and Bogue sounds) with its tributaries and wetlands. (See the map on page 9.) On the west side of the system, numerous rivers discharge freshwater into the sounds while on the east side of the Pamlico Sound, ocean water flows in and mixed freshwater and ocean water flows out through tidal inlets. (Albemarle Sound has no direct link to the open sea.) Both riverine flow and tidal ebb and flow are important forces at work in the estuarine system, but the most important force in this shallow system is wind.

Winds whip up waves that mix the waters vertically, and they push and pull water from one part of the system to another. In addition, the interaction of freshwater and saltwater constitutes a force which plays an important role in the dynamics of the system. When there is not enough wind to mix the water vertically, freshwa-

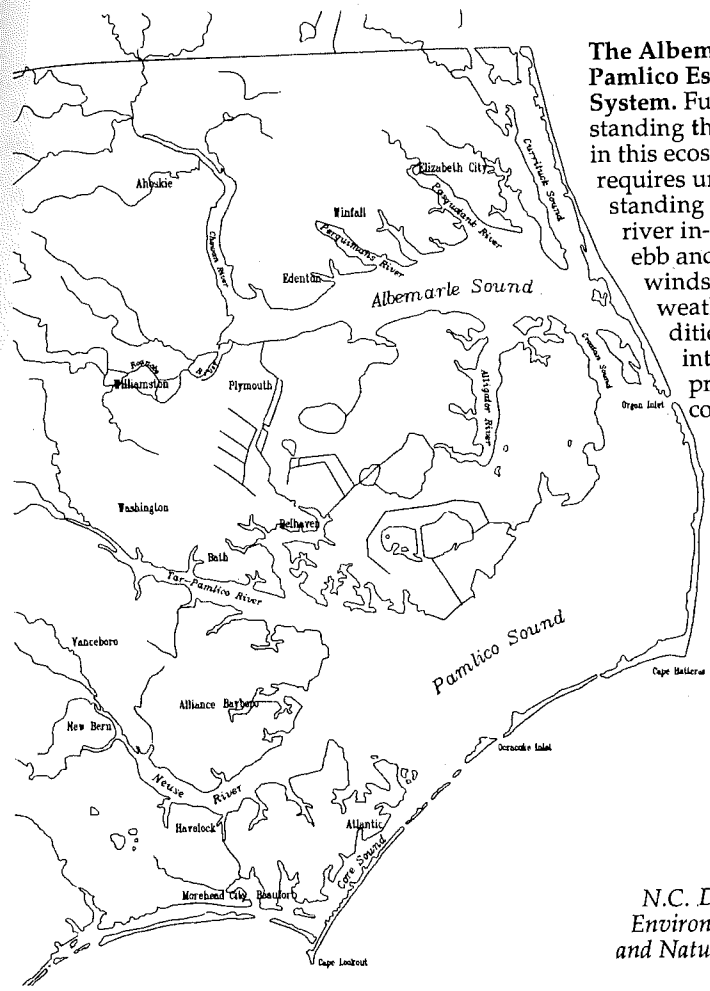
ter flowing into the system can trap heavier saltwater along the bottom—a process called stratification.

While not exactly a force, weather patterns also affect the dynamics of the Albemarle-Pamlico Estuarine System. Drought may reduce freshwater inflow to the system and allow salt water to penetrate further into the rivers. Conversely, periods of heavy rain may increase freshwater inflow and have the opposite effect. Hurricanes and storms like Northeasters can push very large volumes of water in and out of the sounds, causing major swings in salinity, depositing great loads of sediment, and bringing great numbers of larval fish into the sounds.

As all these forces continually push, pull, mix, stratify, and remix water in the system, they also affect numerous biological and chemical processes. For instance, river inflow delivers suspended particles of soil and other materials to the system. Chemical substances adsorb onto the particles, which are deposited onto the estuarine floor as sediment. Wind mixing of the system may later re-suspend the particles, making the substances adsorbed onto them more biologically and chemically available.

The interactions of all these natural forces and natural processes can produce events that humans do not welcome. Stratification can lead to anoxia (oxygen depletion in the bottom water) which can cause fish kills. Re-suspension of sediment by wind mixing can provide nitrogen at critical times and help trigger runaway algae growth. A long-term change in the salinity of a certain area brought on by weather patterns or other factors may lead to a change in the species of aquatic life that can live there. Slight changes in the hydrology of the system can affect the quantities of young fish and shellfish that come into the sounds, which can lead to fluctuations in fisheries yields. Sediment deposited by storms and other disturbances can cover oyster and clam beds and suffocate the shellfish. These, and other events that we consider undesirable, happen without any help from humans. For this reason, it is necessary to have a detailed understanding of the dynamics of the system and the conditions that result from these complex interactions in order to accurately assess the human impact on the system.

We all have a "common sense" science that is based on our day-to-day observations of and interactions with the world around us. Often our scientific intuition is quite accurate, but sometimes things are a great deal more complex than we perceive. The perceptions and experiences of people who live around and use the estuaries have served to guide the Albemarle-Pamlico Estuarine Study technical committee in identifying several "problems" that the study should attempt to solve. This booklet presents those problems as they are perceived and what is known about the conditions that cause them.



The Albemarle-Pamlico Estuarine System. Fully understanding the changes in this ecosystem requires understanding the ways river in-flow, tidal ebb and flow, winds, and weather conditions interact to produce constantly changing natural phenomena, such as stratification, salinity changes, and sediment re-suspension. *Map by Land Resources Information Service (LRIS), N.C. Department of Environment, Health and Natural Resources.*

The Water Quality Problem as It Is Perceived

Pollution is choking life-giving oxygen out of our coastal rivers and estuaries and creating vast areas of "dead water."

The Water Quality Problem as It Can Be Documented

Many pollutants can be thought of as being a lot like weeds: they're substances that have gotten into a medium where they're not wanted in large enough amounts to threaten the things you do want to grow there.

Many of these "pollutants" are harmless if they stay in the right place or if they don't become extremely concentrated. Fresh

water, for instance, is considered a pollutant when too much of it dilutes brackish (that is, salty) waters that need to have a certain degree of salinity in order to serve as nurseries and habitat for certain species of fish and shellfish. There is evidence that in some North Carolina coastal localities—near ditched and drained agricultural areas and near heavily paved urban areas—freshwater drainage is heavy enough during certain seasons to damage nearby nursery and habitat areas. There is also evidence that during certain times of the year, freshwater dilution is making it possible for various kinds of freshwater microorganisms to live and at times become dominant in normally brackish areas.

Freshwater drainage brings with it other substances. Some—like pesticides from lawns, forestry operations, and agricultural fields and toxic organics, oils, and metals that wash off city streets and parking lots—are totally undesirable. But others, in and of themselves, are not harmful.

Nitrogen and phosphorus are nutrients that are necessary for plant growth and are needed in aquatic environments to support primary productivity–the process by which organic matter at the base of the food chain is created. Nutrients such as nitrogen and phosphorus tend to become naturally concentrated in most water bodies over long periods of time, and this process, called eutrophication, usually causes primary productivity to increase, particularly when other factors such as temperature, sunlight, and the rate of flow in a water body, are favorable.

Eutrophication is not necessarily a bad thing: it's what accounts for the development of good fishing in ponds, lakes, and streams. But cultural eutrophication, which is eutrophication speeded up by man's inputs of nutrients to water bodies, does cause problems, the most obvious of which is algae blooms.

The term "algae bloom" refers simply to very dense algae growth. Algae blooms are undesirable because (1) certain kinds of algae may be toxic to fish or shellfish, to animals, and to humans that eat fish or shellfish contaminated by them; (2) at certain times algae consume oxygen, depleting dissolved oxygen in the water and sometimes causing fish kills; (3) when algae colonize a locality they may change the food chain and drive away some species; (4) the various effects of algae blooms may stress fish and shellfish and help make them susceptible to disease; and (5) algae smell bad, make water taste foul even after it has been treated, and discourage swimming, boating, and other water recreation.

Certain levels of both nitrogen and phosphorus are needed to maintain primary productivity in an aquatic environment, and certain levels of both are needed to stimulate algae blooms. Research has shown that the loading of phosphorus in North Carolina's coastal rivers and estuaries is high all year round; therefore, there is nearly always enough phosphorus to support algae blooms. However, there is not always enough nitrogen to support algae blooms. (This is why scientists say the system is nitrogen limited.) In the wet winter and spring months, though, nitrate in agricultural, forestry, and land-development runoff loads coastal rivers with additional nitrogen. Then, as drier weather sets in and flow rates in the rivers decrease, the nitrogen-enriched water is retained in the lower, wider, slower-flowing segments of the rivers, and when summer produces favorable temperature and sunlight conditions, blooms occur.

Once water from coastal rivers gets out into the more open lower estuary areas, it has essentially been stripped of nitrogen by nitrogen-fixing organisms,including algae, so, historically the more saline areas of the system have not been threatened by algae blooms. Now, however, scientists are beginning to investigate whether acid rain, which is rainfall with a pH below 4.5, could supply the limiting nitrogen that would be needed for blooms to occur in the lower estuaries and open sounds. Acid rain contains about eight times as much nitrate as normal rain, and no one knows yet what effect the direct input of nitrogen from acid rain might have on a system that has historically been nitrogen limited.

There is considerable scientific evidence that the entire Albemarle-Pamlico Estuarine System receives too much phosphorus all the time, and too much nitrogen in months immediately preceding the seasonal hot, dry period, when it will not be flushed out of the system. Both nutrients must be controlled in order to decelerate eutrophication of the estuarine system. Regional and city wastewater treatment plants and certain industrial dischargers as well as runoff from agricultural fields, forestry operations, and developed areas add both nitrogen and phosphorus to coastal rivers.

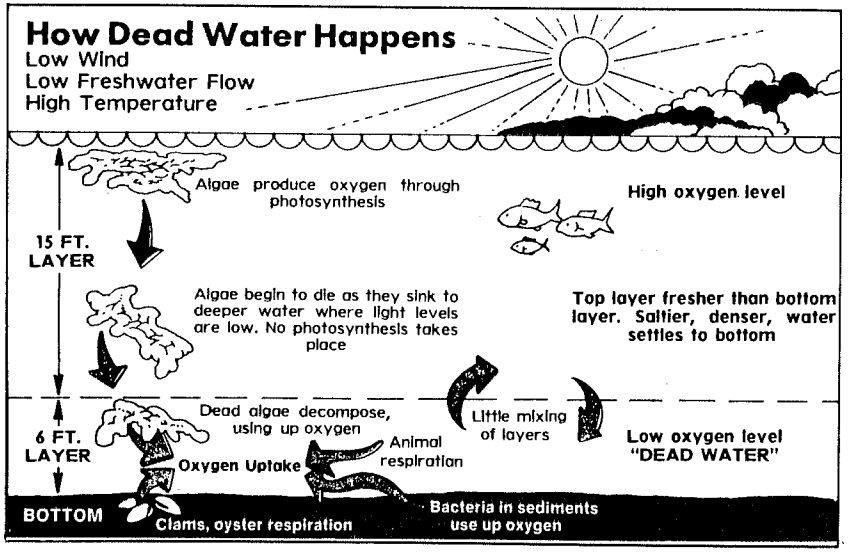
Water pollution that causes shellfish beds to be closed to harvesting is quite different from the pollution that causes algae blooms and disturbs nursery areas. Shellfish harvesting is forbidden when fecal coliform bacteriatests indicate that the shellfish have been contaminated by pathogens from animal wastes. This kind of pollution reaches estuarine waters when nearby malfunctioning septic tanks leak untreated human waste and when storm runoff washes animal waste into creeks, rivers, and estuaries. Evidence that this kind of pollution affects North Carolina's coastal waters is that currently 320,000 acres are closed either permanently or temporarily to shellfish harvesting. (Not all of these acres are productive shellfish beds.)

The most puzzling water quality problem to affect estuarine areas is anoxia (sometimes called hypoxia). This condition can kill fish and shellfish that can't get out of the oxygen-depleted area quickly enough. It's what drives crabs out of the water onto land and

sends fish to the surface gasping for air. While some oxygen depletion events can be attributed to algae blooms, many cannot. Most often, anoxia events are caused by stratification. When stratification occurs, water from the surface is not being circulated down, so no oxygen is being delivered to the bottom. Eventually all the oxygen in the bottom water is consumed by organisms in the water and sediment.

Stratification conditions arise in the Pamlico and Neuse river estuaries mostly in the summertime, and that's when most fish kills occur. However, winter anoxia and winter fish kills occur, particularly in the Pamlico River Estuary.

Scientists don't agree about whether there are a greater number of summer anoxia events in the Albemarle and Pamlico systems now than in the past. Many citizens and some scientists think that there are more anoxia events because there appear to be more fish kills than there were in the past. On the other hand, some scientists and state environmental officials point out that adequate records of fish kills go back only about five years—which isn't long enough to establish a long-term trend, and even records of the last five years don't conclusively show an upward trend in the number of fish kills. Furthermore, they say an increase in the number of reported fish kills could be attributed to the fact that there are more people—and therefore more potential observers and reporters of fish kills—in the estuarine areas than in the past.



Anoxia or Oxygen Depletion in Bottom Waters. It is unclear whether "cultural eutrophication," the accelerated increase in nitrogen and phosphorus levels in waters, contributes to this phenomenon. A recent study in the Chesapeake Bay attributed most anoxia events there to stratification. *Graphic by Jim Stanley, Winston-Salem Journal.*

There is also some scientific disagreement about whether cultural eutrophication—the accelerated increase in nutrient levels in waters—contributes to anoxia. Some scientists think that higher levels of nutrients increase the growth of bottom-dwelling microorganisms that consume oxygen. Others point to a study done in a similar estuarine system, the Chesapeake Bay, that concluded anoxia events in that stressed system have not increased over the last 35 years and that stratification, not oxygen consumption by bottom-dwelling microorganisms, is the primary cause of anoxia there.

Some things we classify as water pollutants wouldn't be welcome anywhere—toxic chemicals and heavy metals, for instance, and some rivers and estuaries in the United States have problems with high concentrations of toxic chemicals and heavy metals in the sediment, or soil that has been deposited on the bottom. Research has turned up a few widely scattered spots in the Pamlico River where the sediment contains elevated metal concentrations, but generally speaking toxics and heavy metals are not a major problem in our coastal waters.

The Submerged Aquatic Vegetation (SAV) Problem as It Is Perceived

Water pollution is killing and preventing re-establishment of underwater grasses that many kinds of fish and shellfish depend upon for food and shelter from predators.

The SAV Problem as It Can Be Documented

Submerged aquatic vegetation (underwater grass) is a critical component of the coastal ecosystem, and coastal North Carolina is home to a unique SAV community. Here, in higher salinity waters, eelgrass and shoalgrass coexist with widgeongrass, and because these grasses grow in overlapping seasons, their unique coexistence provides year-round habitat for many species. A wide variety of creatures depend upon SAV for food and refuge from predators. For instance, SAV is the major nursery habitat for North Carolina bay scallops. SAV also provides food for many kinds of birds. Some birds eat the grass itself; others birds and fish eat microorganisms nourished directly by the plants. SAV is also important in the brackish waters in the western portions of the system and Currituck Sound.

SAV that grows in higher salinity waters is called marine SAV. North Carolina has a larger area of marine SAV than any state besides Florida, and marine SAV appears generally to be stable and healthy. However, evidence is emerging that some areas of marine SAV may be impacted by what's being described as a "wasting-like" disease. The "wasting disease" caused significant damage to marine SAV beds in the 1930s.

More importantly, the abundance of marine SAV may be threatened by dredging, filling, and shellfish harvesting practices, particularly clam kicking. Requests for permits to dredge and fill areas near obvious SAV habitat are increasing, and a lack of understanding about the growth patterns of SAV may be leading to destruction of SAV habitat. SAV grow in patchy beds. Within a general area the specific spots covered by vegetation will shift, but the total area covered will tend to remain about the same. If bottom area that is not currently covered but is part of the resident SAV habitat is allowed to be altered, the total area of that habitat will have been cut and the amount of vegetation will shrink proportionately.

The primary concern about SAV, however, centers on seagrasses growing in the estuaries and rivers—what's called brackish water SAV. These communities are evidently in drastic decline. But, because observational records are short and because little research has been done on brackish water SAV, it's unclear whether the decline is caused by natural fluctuations and is temporary—or is caused by man-made pollution and is permanent.

The longest observational records of brackish-water SAV in the Albemarle-Pamlico system are of SAV in the Currituck Sound. Up until 1918 there were lush meadows of SAV in the Currituck Sound; then there was a drastic decline. The deterioration was attributed to pollution from a canal system discharging into the sound and turbidity from dredging. After locks were installed on the canal, the situation improved, and by 1967 a species of seagrass called watermilfoil was widely established. But, by 1978, the watermilfoil had declined to half its 1967 abundance. That decline was attributed to unusual weather conditions in 1973 that caused turbulence and turbidity in the sound.

Biologists generally agree that the most critical single environmental factor for SAV is the availability of light. When waters stay churned up for a long period and turbidity is high because of suspended particles in the water, less light—needed for photosynthesis—gets through to the grass. Turbidity can result from heavy rains and increased streamflow, and from wave action. Heavy rains also dilute the salt content in brackish waters, which may have negative impacts on submerged grasses.

When excess nutrients stimulate algae in waters, increased algae growth can reduce the amount of light reaching submerged plants and cause their decline.

Other environmental factors influence where and how thick SAV grows. The east shore of the Pamlico Sound has extensive SAV meadows while the west shore has relatively little SAV. Here, it is unlikely that water quality factors determine the distribution of the seagrasses. Biologists think that more open exposure to wind and waves may make the west shore a less suitable SAV habitat.

So, while man-made pollution could be contributing to the decline in SAV in areas of the Albemarle-Pamlico Estuarine System, the decline could also be attributable to other factors over which man has little control.

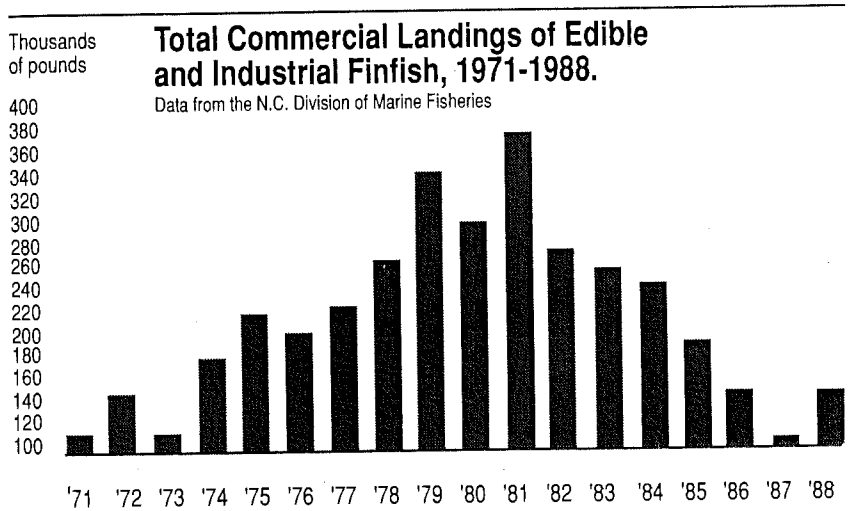
The Fish Resource Problem as It Is Perceived

Fishing isn't what it used to be in the coastal rivers and sounds because changes in the environment are preventing fish and shellfish from reproducing normally, causing the resource to decline.

The Fish Resource Problem as It Can Be Documented

The longest records available that might be used to judge the abundance of fish are those of commercial landings. These records date back to 1880, but while they can be useful, it is important to realize that they are not absolute indicators of abundance because they are strongly influenced by external factors such as prices, market demand, and reporting variability.

Commercial landings records and biological data seem to show that the period of greatest overall fish abundance was 1978-1982. If this is the case, it contradicts the intuition that fishing was much better in the "good old days." In fact, there is evidence (size and age composition) that the fisheries resource was unusually productive during that five-year period.



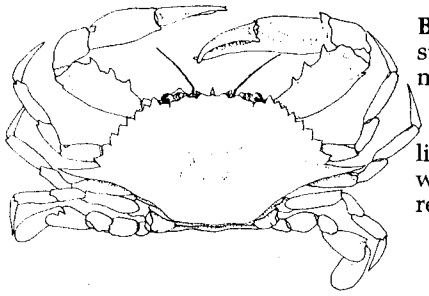
Total Commercial Landings of Edible and Industrial Finfish, 1971-1988.
Data from the N.C. Division of Marine Fisheries

However, it can't be said with certainty that 1978-1982 was a period of greatly increased abundance and not a period of unusually intense commercial fishing effort. In the same vein it can't be said with certainty that the decline in commercial landings after 1982 has been due to decreased fish abundance and not increased recreational fishing and commercial fishing pressure. While landings have declined from the 1978-1982 peak, they are still generally higher than they were in the 1960s and early 1970s.

Recreational fishermen are generally pictured using hook-and-line gear, but in North Carolina they use commercial gear as well. Over half the commercial vessel licenses sold annually by the Division of Marine Fisheries (DMF) are issued for recreational use of commercial gear, and in 1988, more than half the licensed vessels using crab pots were recreational. Several thousand fishermen pull small shrimp trawls for recreation, and anglers frequently set small anchor gill nets and pick them up after fishing for several hours with hook and line. In some coastal areas, cottages rented to tourists come equipped with a gill net. While it's clear that recreational fishermen take significant amounts of fish, their impact on the commercial fisheries has not yet been measured. DMF has begun a sampling program to assess how much fish recreational catches account for.

In the same way that recreational fishermen may be impacting commercial catches, commercial fishermen using one kind of gear may be affecting the catches of fishermen using another kind of gear. Placement of crab pots and pound nets in the Pamlico Sound area during spring through fall, for instance, has eliminated some area available for long-haul seine fishing, so one kind of fishery has displaced another kind to a degree. The results are seen in landings figures, and decreased landings may be interpreted as evidence of resource decline.

Records of commercial landings cannot be interpreted as conclusive proof of a general decline in fisheries, but, along with biological data, they do indicate declines since the early 1970s or before in anadromous fish. Anadromous fish (such as river herrings, shads, and striped bass) spend most of their lives at sea but return to freshwater streams to spawn. Dams and other structures which block the fishes' upstream migration to spawning grounds, stream flow problems, and poor water quality may be responsible for the decline in these species.



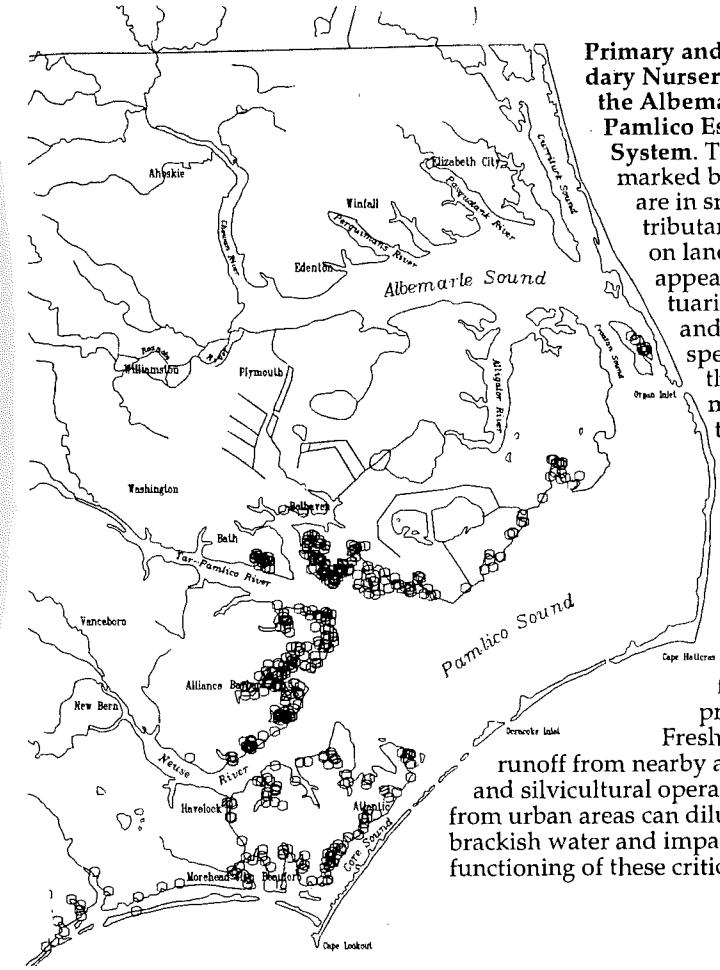
Blue Crab (*Callinectes sapidus*) supports coastal North Carolina's most economically important fishery. Human conflicts over placement of crab pots in estuarine waters are likely to increase since pots interfere with moveable fishing gear and recreational boating.

The Fish Disease Problem as It Is Perceived

Water pollution is giving crabs shell diseases and fish skin diseases that kill large numbers of creatures and make many others unmarketable, thereby contributing to the decline in the resource.

The Fish Disease Problem as It Can Be Documented

The impact of disease on fish stocks is currently unknown but could be severe. Disease may be killing fish outright, although it's



Primary and Secondary Nursery Areas in the Albemarle-Pamlico Estuarine System. The areas marked by symbols are in small tributaries, not on land as it may appear. Most estuarine fish and shellfish species spend the first months of their lives in these brackish water areas where there is plenty of food and protection from predators. Freshwater runoff from nearby agricultural and silvicultural operations and from urban areas can dilute the brackish water and impair the functioning of these critical areas.

Map by LRIS.

unlikely that enough fish have already died from diseases to significantly decrease populations. Of more importance may be the chronic effect of diseases, whereby numbers of fish continue to die year after year.

From the standpoint of marketability, of course, diseases make food fish almost worthless, so, even if disease isn't killing fish, it could kill the fisheries.

Precisely what water quality factors are causing diseases affecting fish in the Albemarle-Pamlico system is still open to debate. No direct links between any water quality factors and disease have been discovered. It may be that a number of factors work together to stress fish, suppress their immune responses, and make them vulnerable to aggressive infection by rather common organisms. Investiations indicate that shell disease in crabs may be linked to specific constitutients in industrial effluent going into the Pamlico River.

The Wetlands Problem as It is Perceived

The conversion of wetlands for other uses must be stopped because draining or filling wetlands removes a critical water quality control and destroys habitat for many species of plants and animals.

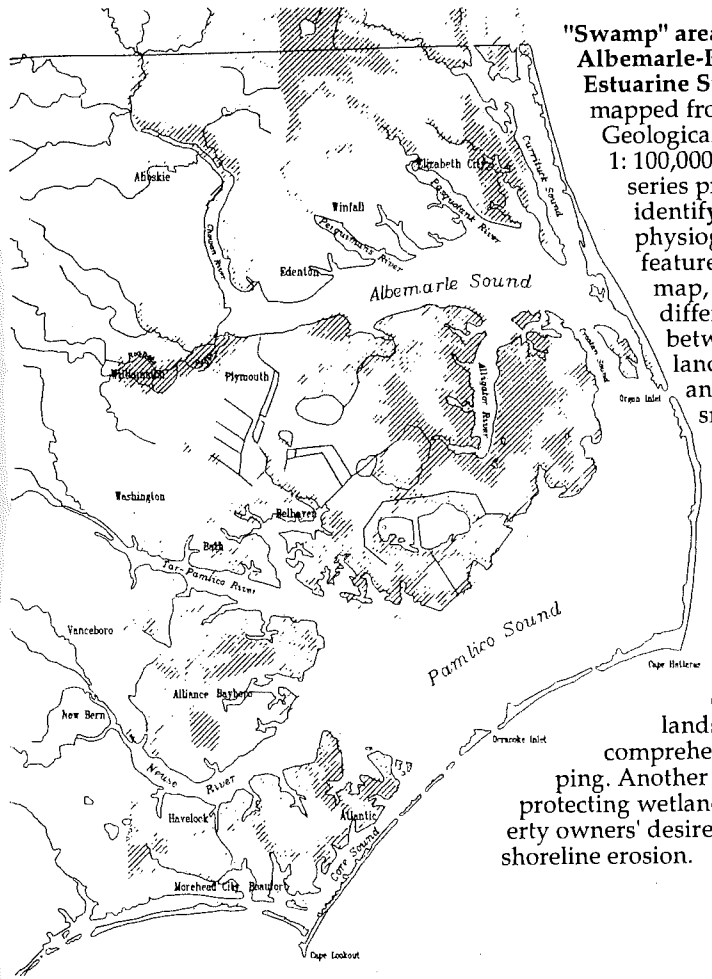
The Wetlands Problem as It Can be Documented

Ecologists have long recognized the crucial role that wetlands play in coastal environments. Because they stand between open waters and uplands where human activities occur, coastal wetlands act as filters, removing sediment and pollutants from water before it drains into the rivers and estuaries. Wetlands also provide food and habitat for many creatures, including fish, shellfish, waterfowl, birds, amphibians, reptiles, and mammals. The kinds of creatures that are found in a certain area depend to a large extent on the type of wetlands dominant in the area, and the abundance of aquatic life is tightly linked to the abundance of wetland habitat. The Albemarle-Pamlico Estuarine area boasts some of the most extensive and unique wetland habitat anywhere.

The diversity and abundance of creatures in the Albemarle-Pamlico Estuarine area is therefore a direct result of the kinds of wetlands found here and the fact that we have vast expanses of wetlands. It follows that if significant portions of our wetlands are destroyed or if activities take place that cause a change in the nature of our wetlands, we can expect changes in the kinds and numbers of creatures in our estuarine system.

North Carolina's shoreline ecology is different from any other. Because the barrier islands, or Outer Banks, restrict the exchange of water between our estuaries and the ocean, our estuarine system is less salty (the Albemarle Sound is essentially a freshwater sound) and is less affected by tides than other estuaries along the Atlantic Coast. This unusual setting creates extensive fringing wetlands that are unique because they are of the brackish to freshwater type and are not regularly flooded by tides. More common wetland types, such as salt marshes that are flooded by tides, also occur in some areas of the Albemarle-Pamlico system.

In the Albemarle Sound area, nontidal, freshwater conditions favor development of forested wetlands rather than marshes, and



Map by LRIS.

"Swamp" areas in the Albemarle-Pamlico Estuarine System mapped fromthe U.S. Geological Survey 1: 100,000 scale map series produced to identify major physiographic features. On this map, there is no differentiation between wetland types and many small wetland areas may not be represented. One of the obstacles to adequately protecting our wetlands is lack of comprehensive mapping. Another obstacle to protecting wetlands is property owners' desire to prevent shoreline erosion.

well over 100 kilometers of shoreline are occupied by forested wetlands in this region. Swamp forests along the edge of the estuaries are the shoreline version of the interior swamp forests that they merge into, and many of the same kinds of trees and plants are found in fringe and interior swamp forests. Along the estuarine shoreline, fringe forested wetlands provide complex habitat. Fallen logs and exposed roots harbor a variety of terrestrial and aquatic creatures and shallow waters sheltered by trees encourage beds of submerged grasses. Erosion of the shoreline maintains this habitat, so it is necessary for habitat protection that the natural erosion process be allowed to continue. Landowners in the estuarine system often see erosion as an enemy eating away at their property, and they attempt to stabilize the shoreline by building seawalls.

While forested wetlands are the dominant wetland type in the Albemarle Sound, in the adjoining Currituck Sound there are significant areas of nontidal freshwater marshes, mostly in the northern part. Freshwater marshes in the Currituck are composed mostly of plants like cattails, arrowheads, and chair-maker's rush, although some plants that like saltier water (such as black needlerush) can also be found here. Freshwater marshes in the Currituck support waterfowl and sport fish, such as bass, and so help provide good hunting and fishing in the area. Threats to these freshwater marshes include any change in the salinity of the waters—which could result from the opening of an inlet to the Currituck Sound, and destruction by residential and recreational development.

In the Pamlico Sound area, nontidal, brackish water conditions produce marshes dominated by black needlerush bordering the open waters of the estuary. Nontidal brackish marshes are the most important wetland type in the Pamlico Estuarine System in terms of surface area and proportion of shoreline. In most locations where this kind of marsh appears, it is accompanied by smooth cordgrass communities that occupy a position between it and the open waters of the estuary. In the Pamlico, however, an intervening zone of cordgrass is not present, so the black needlerush marshes directly interact with the open water. This direct interaction is unusual, and it has not been extensively studied. There has been a tendency to view nontidal brackish marshes as less valuable as producers of food for aquatic life than tidal salt marshes. Because nontidal brackish marshes are composed of species that are not important food producers in other coastal ecologies and because it has been assumed that tidal action is necessary to transport food produced by marsh plants to open water, these marshes have been undervalued. However, because nontidal brackish marsh is the dominant type in the Albemarle-Pamlico Estuarine System, it must be a critical food producer in this ecosystem. In addition, while salt marshes may be better primary producers than brackish marshes, a saltier environment is a more severe environment, so salt marshes do not harbor the richly diverse communities of life that brackish water marshes

do. Brackish marshes serve as both primary and secondary nursery areas for many commercial and recreational species.

A critical geologic feature of coastal North Carolina is that the Coastal Plain area east of an ancient shoreline called the Suffolk Scarp (several miles west of the present shoreline) is virtually flat. Since the landscape is flat and interfaces with the sounds, water doesn't drain off the land readily. This means that a vast expanse of coastal North Carolina is really more like wetlands than uplands—with a high watertable and with vegetation that is adapted to swampy conditions. This feature of coastal North Carolina is important to understand because it means that entire coastal landscapes—not just shoreline wetlands—are influenced by the ocean. It also means that as the sea level rises, as it has been doing for several hundred years and is expected to continue doing at an accelerated rate for hundreds more, large areas of the coast may be subject to inundation.

Conventional wisdom about coastal wetlands says that, under normal rates of sea-level rise, wetlands will "migrate" inland, spreading on the landward side as they are eroded by the action of water on the ocean side. That model of wetland migration, however, is based on a coastal typography that grades gently upland, providing a slightly higher elevation for the wetlands to "climb" onto. Since North Carolina's coastal typography is essentially flat, however, this model doesn't apply well.

Historically, North Carolina's coastal wetlands have been able to build up surface area. The extensive peat deposits inland in the Coastal Plain were created by wetlands thousands of years ago when the shoreline was further to the west than it is now. Today, many parts of Dare County would be underwater if fringing swamps had not accumulated peat and sediment and built up surface area that swamp forests can live upon.

Whether our coastal wetlands can repeat this process and build up bogs to elevate themselves above the rising sea is a major concern. One problem is that the sea is rising faster now than it did during the previous interglacial period when the sea pushed forests and marshes inland. Another problem is that human structures may block the path of wetlands as they attempt to migrate.

In the Pamlico Estuarine system, hundreds of hectares of marsh have been ditched in an effort to control mosquitoes, and the effects of this ditching on the function of the marshes—and most importantly on their ability to maintain surface area—has not been determined. In addition, impoundments created at several sites in the area in an effort to attract waterfowl have altered the exchange of water between the marshes and estuary, thereby changing the salinity and threatening the brackish water marsh species. In many places along the estuary, dikes and bulkheads have been built to protect

homes and other property from erosion. These structures prevent migration of marshes, and as rising sea level floods them, the marshes will simply disappear.

So, while draining or filling or dredging shoreline wetlands in order to construct buildings or marina operations does decrease the natural productivity of the estuarine system, other practices are also harmful. Moreover, because our coastal wetlands extend inland from the shoreline great distances before blending into the upland landscape, the draining and filling of more inland wetlands could be affecting our estuarine environment in ways we have not yet documented, and simply preventing further wetland loss may not be enough. To sustain the historical productivity of the estuarine system, we may need to restore impaired wetland areas that border fringing wetlands.

The unique plant communities in our wetlands support a variety of creatures—invertebrates, amphibians, reptiles, mammals, birds, and fish. This ecological network is of economic, aesthetic, and evolutionary significance to the region. Unfortunately, up until recently, we have not attempted to map our wetlands in a consistent and comprehensive format, so it is very difficult to assess long-term status and trends. We do know that some North Carolina wetland types are of national significance because of their uniqueness and extent. And, we do know that in recent years, large acreages of wetlands have been converted for other uses.

Summary

Designated as one of the nation's estuaries of concern, the Albemarle-Pamlico Estuarine System has become a focus of attention for the U. S. Environmental Protection Agency, the National Oceanic and Atmospheric Agency, the N. C. Department of Environment, Health and Natural Resources, state and national visual and print media, and, indeed, the people whose heritage, and recreational, commercial, and aesthetic values are rooted in coastal North Carolina. We are involved in a cooperative and concerted effort to assess and better manage this important area to reverse the perceived ecological declines.

The Albemarle-Pamlico Estuarine System is extremely complex—ecologically and as a human environment. The hydrographic, geologic, geographic, and socio-economic conditions have created an area uniquely diverse biologically, aesthetically, and economically. It is important to North Carolina, the region, and nation. If we are to manage the system more effectively, we must better understand how it functions as an ecological whole and how human uses impact it. In some cases, we know enough about individual processes to make wise decisions; but in most cases, we don't understand how processes interact. That means we cannot yet integrate what we know

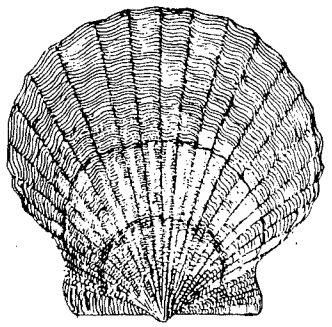
into a holistic understanding of the system. We need to reach a better understanding so that the officials who manage the estuarine resources can consider how processes interact when they make decisions about such things as granting permits and establishing regulations.

People who use the estuarine complex have seen indications of problems and potential problems. Some of these are indications of declines in productivity, aesthetic, and socio-economic values, while many are results of conflicts in uses and traditions. Sometimes the estuarine system's inherent value is ignored and its ecological integrity is threatened because it is thought of as a resource to be used in whatever way we humans may choose.

Thus, there are two sides to the problem that the people of North Carolina must address in dealing with the Albemarle-Pamlico Estuarine system. One side involves preserving and/or managing the ecological integrity of the natural system; the other side involves the resolution of human conflicts over uses of the resources. Since no problem or use exists in isolation, it is important that we have a comprehensive management plan based on an integrated understanding of the entire system.

Many regulations and laws as well as extensive conventional wisdom exist to deal with changes, uses, and conflicts. In many cases, however, these conventions are applied in uneven ways, in isolation and after-the-fact—not maliciously, but in the absence of comprehensive and pervasive knowledge of the total system. Often, better results can be realized if we apply existing management schemes in a more integrated fashion. This approach will require extensive interaction among all user groups and the concentrated attention of the people involved in all aspects of the Albemarle-Pamlico Estuarine System.

The future of the Albemarle-Pamlico Estuarine system rests in the hands and hearts of its owners—the people of North Carolina.



Bay Scallop
(*Argopecten irradians*)
Seagrass beds are critical habitat for this species.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