University of North Carolina Sea Grant
Coastwatch
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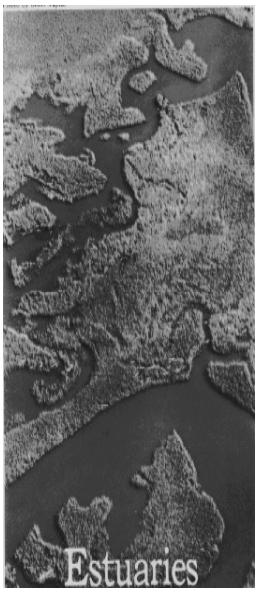


Estuaries

Estuary. It's one of those scientific terms that is gradually creeping into our common language. You hear a news reporter use it on the air. You see it printed in National Geographic. But it's a word just on the verge of becoming common, and there is confusion about what it means.

Fishermen don't bother with the word at all. It's a word they say dit-dots (scientists, in down-east lingo) use. To fishermen, the estuary is Rose Bay, South Creek, Bogue Sound, the Neuse River, places where the fishing is good.

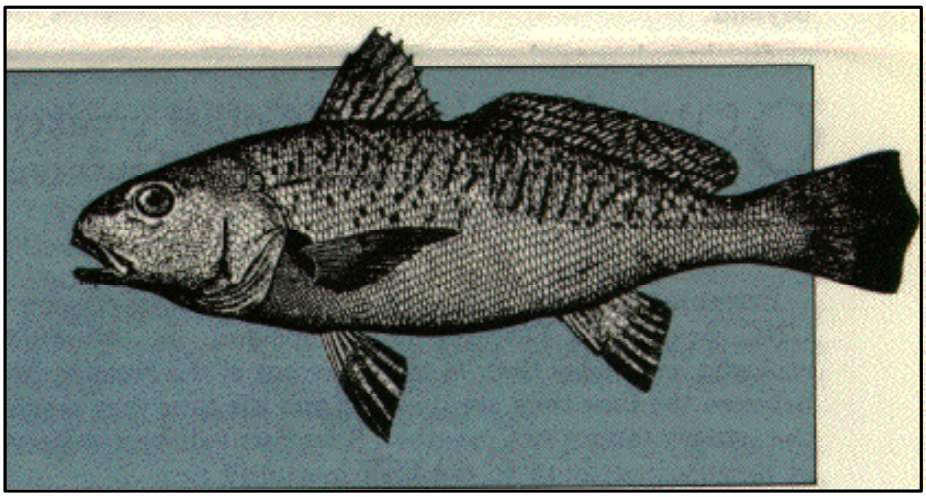
Well then, what is an estuary? It's a place where the salt water and fresh water mix it up. But there's more to it than that. There are fish, marsh grass, circulation patterns, nursery grounds and more. Things that make the estuary special.

We asked six Sea Grant scientists—B.J. Copeland, John Miller, Charles Peterson, Hans Paerl, Stan Riggs and Scott Snyder—to tell us a few things that make the estuary different; to tell us a few things that make the estuary interesting to them. They put together some facts and added up some figures. Here's what we learned:

Over 5,874,000 North Carolinians own Rose Bay. You may not be able to have it surveyed, staked off and fenced in, but you do own a small parcel of that submerged land.

Just as you own part of all the state's estuarine system. We all have a stake in the state's approximately 2.3 million acres of estuaries because they're in the public domain. It's like owning part of your own farm at the sea. And, North Carolinans hold the deed to more estuarine land than people in most other states. We have the largest estuarine system on the East Coast and the third largest system in the United States. Only Louisiana and Alaska have larger estuarine systems.

Biologists believe 90 percent of the state's commercially important species spend at least part of their lives in the estuary. For example, in 1982 the state's fishermen received $16.4 million for their shrimp catches, $7.4 million for blue crabs and $5.8 million for menhaden. The estuary serves as a nursery for each of those species and many fishermen owe their livelihoods to that estuarine nursery.



The mother croaker lays 100,000 eggs

The mother croaker has just cast 100,000 eggs into the western edge of the warm Gulf stream on a cold December day. Now it's up to the warm waters to incubate the eggs until they hatch the one- to two-millimeter larvae several days later.

The ocean isn't a very hospitable home for the newborn croaker. But there is a place that specializes in nursing baby fish, finfish and shellfish—the estuarine nursery. John Miller is intrigued by the life cycle of commercially important species like croaker. And he believes the months spent in the estuary may be critical to the species' survival and maintenance. After all, the larval croaker wouldn't travel 100 miles to places like Rose Bay unless there was something to be gained there, Miller says.

The mother croaker has set her offspring on a time schedule that puts them at all the right places at all the right times. And this sense of timing may be one of the reasons why croaker are so abundant. Croaker, along with spot, menhaden, and two species of flounder, follow a similar time schedule for spawning, transport back to the coast and arrival in the estuary. These five species make up 85 percent of the state's commercial catch by weight.

Unable to swim, the larval croaker hitch a ride westward on the ocean express. Miller and other scientists believe the larvae ride an intermediate layer of warm ocean water that flows shoreward during the winter. If croaker spawned any other time of the year, their ride to the estuary might not be available.

About January, millions of baby croakers bombard the coastline in search of an inlet to the estuary. Once in areas like Pamilico Sound, the larvae settle to the bottom for another ride to the nursery. Winter winds blow surface waters against the barrier islands. Gravity pulls bottom waters in the opposite direction. By settling to the bottom, the larvae are driven westward into nursery areas like Rose Bay.

Again, time is on the side of the croaker. The larval croaker settle into the nursery between February and May, just in time to catch the estuary's peak productivity during the late spring.

"The croaker grow like crazy in this environment," Miller says. The larval croaker quickly become juveniles, growing from 25 millimeters to five inches during their five-month stay. The juveniles eat clam siphons, copepods, benthic worms and mysid shrimp.

And the estuarine nursery seems to provide some protection from predators. Miller has learned the nursery can be an inhospitable place for adult fish who might prey on juvenile croakers. Temperatures and salinity levels fluctuate. As long as the fluctuations aren't too drastic, young fishes, such as the croaker, can withstand the changes. But adult fish aren't as tolerant of environmental stresses, Miller says. Adult fish tend to avoid the nursery areas, choosing deeper waters.

After completing their growth spurt, juvenile croaker leave the nursery behind about August, graduating to the deeper waters of the estuary or the nearshore ocean waters beyond.

Of the 100,000 eggs the mother croaker spawns, odds are, only one will survive to become an adult.

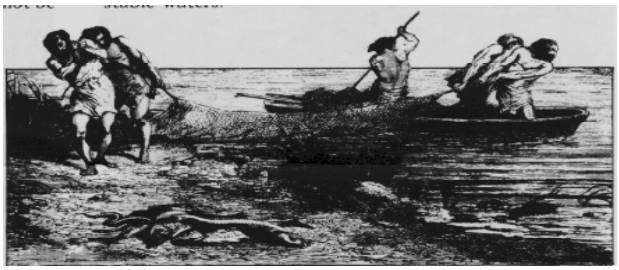
Percentages aren't on the side of the newborn croaker. UNC Sea Grant Director B.J. Copeland, an estuarine ecologist, estimates that 98 to 99 percent of the croaker die between the time they are spawned and the time they reach the estuary (about two months). Scientists believe a variety of factors contribute to the high mortality rate.

As eggs and young larvae, the baby croaker float among the plankton, becoming prime targets for hungry fish. Many die from natural causes—genetic deficiencies, deformities. Others die from environmental stresses. Some never find the right currents to carry them shoreward. And the croaker are so tiny, scientists have a hard time tracking them through their early days to learn exactly what happens to the baby croaker.

The estuarine nursery offers the baby croaker a better chance. In Rose Bay, three percent of each day's remaining balance of croaker die, says John Miller. Again, factors like predation and environmental stresses such as salinity and temperature changes contribute to the croaker's demise.

But for the croaker who survives to leave the nursery, the odds are favorable. The croaker, now about five inches long, has fewer predators and has moved to the deeper, more stable waters.

Nearly 17,000 years ago, stone-age fishermen would have been living in their villages at the outer continental shelf edge, about 25 miles east of Cape Hatteras.



When the last major ice age began about 35,000 years ago, the North Carolina coastal and estuarine system would have been in a geographic position similar to today. But, it didn't stay there, says Sea Grant researcher Stan Riggs.

Within 17,000 years, glacial ice extended into the northern United States and sea level had dropped about 400 feet. Riggs says the entire North Carolina continental shelf would have been exposed and the estuarine system would have been near the edge of the shelf.

Thousands of years later, the climate warmed again, sea levels rose and waters flooded the river basins, forming today's estuaries.

Such warming and cooling trends take thousands of years, says Sea Grant researcher Scott Snyder. Right now, the earth is in a warming trend, he says.

If that trend were to continue and all the glacial ice in Greenland and Antarctica were to melt, the world's shorelines would eventually be about 200 feet higher than they are now, says Riggs. "This would put the entire coastal plain of North Carolina under water with the shoreline occurring approximately along Interstate 95 between Roanoke Rapids and Fayetteville."

But coastal residents don't have to pack up and move yet, says Snyder. He says most geologists estimate that sea level is rising a half a foot per century. So, we can expect the estuaries to stay put for a while.

Photo by Scott Taylor

Understanding the estuary also means understanding the people who use it

A molecule of one nutrient may stay in the estuary for years.

Perhaps a molecule of nitrogen arrives in the estuary. There, it finds itself taken up by marsh grass, or maybe by algae or seaweed. When the grass dies, the nitrogen is released and deposits itself in the sediments where it's covered up by more sediment.

Months may go by before something, perhaps a shrimp, disturbs the sediments, sending the molecule back into the water column. Then the process begins all over again.

Estuaries are nutrient traps, says Sea Grant researcher Hans Paerl. "There is a net loss but it can be years before nutrients are released from the estuary."

The sediments in an estuary tend to adsorb (the nutrients attach to the sediments) nutrients and the circulation patterns of the estuary make it easy for them to stay there. A particle might be carried toward the sea by the freshwater flow at the surface and then returned upstream by the tidal currents below, says Sea Grant researcher Charles Peterson.

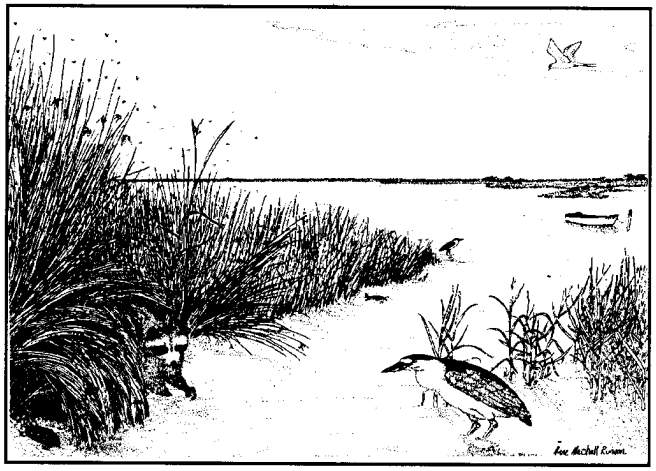
That explains why estuaries have a much higher concentration of nutrients than the sea or than the fresh waters draining into the estuaries, says Peterson. Nutrients stimulate plant growth, resulting in the high productivity for the estuary. According to some estimates, an acre of a North Carolina estuary is more productive than an acre of farmland producing rice, corn or hay.

A farmer may work year after year, cultivating, fertilizing and irrigating his soil. Without all the nurturing, the nutrients would eventually be used up. Not so with an estuary. Paerl says the continuous inflow of fresh water provides the estuary with all the nutrients it needs.

"Most of those nutrients come from the freshwater environment and the estuary's fertility is due to that freshwater system. But there's a fine line between an adequate amount of nutrients and an excess," says Paerl. An excess of nutrients can cause undesirable levels of algal growth .

North Carolina's Pamlico Sound is one of the most productive estuaries in the world.

If Pamlico Sound were a bank, it would have one of the richest stockpiles of assets in the world. But the assets in Pamlico Sound are measured in terms of pounds of fish, bushels of shellfish and acres of marsh grass. The dividends from the production of fish and shellfish are easy to calculate. But dividends also accrue from more obscure things like benthic worms, seagrass beds, phytoplankton and bacteria. They are all part of a simple, but lucrative food chain that adds up to a system rich in productivity.



Sea Grant researcher Charles Peterson wanted to compare productivity in two different estuarine systems to see how they stacked up. He chose a creature common to both systems—the clam—to test in estuaries located in southern California and in North Carolina's Back Sound, part of the overall Pamlico Sound estuarine system.

Using wire-mesh cages to exclude predators, Peterson laid one layer of clams "cheek to jowl." On the shoulders of the first layer, he laid another layer of clams to double the density. Peterson wanted to learn if a change in density would affect the clam's growth rate. "I wanted to get an idea whether the availability of resources were a limiting factor in growth," Peterson says.

In similar studies in California, Peterson had found that the growth rate of clams was cut in half when their density was doubled. But in Back Sound, double density meant double production. Why the difference? Food availability. The North Carolina clams had all the food they could eat. The California clams didn't.

The physical properties of the estuary help make it so productive. Nutrients are supplied from upstream rivers and the ocean. But North Carolina's shallow estuarine basin traps the nutrients and recycles them for continued use. In the California system, fewer nutrients are supplied from upstream and the estuarine basin is deeper, allowing less nutrient recycling.

If food is so plentiful, why aren't we waist-high in hard clams in Back Sound? The answer is simple. What's good for the hard clam is also good for the blue crab, the conch, the ray and the snapping shrimp, all predators of the hard clam. The food chain works to balance the account of the estuary's depositors.

The estuary plays an important role as a feeding area for birds.

For migrating birds preparing to make a pit stop for food, the estuary is the best restaurant in town. Birds require a lot of food to fuel their rapid

metabolisms. Naturally, they head for the place that offers the most food for the least amount of effort—the estuary. Whether the bird is a short-billed dowitcher probing for benthic worms or a least tern diving for fish, it can find large quantities of food in a relatively small area in the estuary.

Researchers have noticed that fall and spring migrations of shallow-probing birds such as the red knot or the American golden plover differ in length and intensity. Shallow-probing birds dine along intertidal flats, eating polychaete worms and small crustaceans.

During the spring migration, larger concentrations of shallow-probing birds spend less time in the estuary feeding than during fall migration. Why the difference? Food is more abundant during the spring when the estuary is at peak productivity. And spring tides are lower, offering the birds a larger area to scavenge.

Even seasonal and full-time residents like terns, gulls and egrets benefit from the estuary. While some species of terns and gulls are ocean-feeding species, others feed from the estuary. The shallow estuaries bring even bottom-feeding fishes close to the surface for birds to feed upon. And nearby land masses tend to block the wind, creating a flat water surface where prey are more easily seen from the air.

Because birds feed heavily on a wide variety of estuarine organisms, they tend to serve as a barometer for the estuary's health. Birds come at the end of the estuary's short food chain. And if production were limited or changed in the estuary, either because of man-made or natural reasons, the effects would almost immediately be seen in the birds that feed there.

—Nancy Davis and Kathy Hart