The Importance of the Estuarine Shallows

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South Carolina Department of Health and Environmental Control

Preface

The first European immigrants established their colonies along the east coast of the United States. These men and women modified the habitats found along the coast to suit their desires for commerce, industry and farming. Since the building of the first towns, many of which grew into cities, these coastal areas have been exposed to many negative influences associated with development. The marshes were filled (often with garbage); sewage and industrial effluents were discharged into the bays and estuaries.

One would think with our increased knowledge and understanding of the importance of coastal zone habitats that we would realize the critical need to protect these areas. However, this assumption is not always borne out. In the recent past, there was a letter written by a realtor-developer to the editor of the daily Charleston, SC newspaper describing his reaction to the view from an airplane as it flew along the coast from Charleston to a destination in Georgia. Basically he wrote that the marshes and shallows of the coast between South Carolina and Georgia were a vast wasteland that could be used if man would be allowed to modify (dredge and fill) and develop these sites for commerce and housing. In essence, what good are they if we can't use them. This is not the first time our coastal marshes have been referred to as a "wasteland". However, these coastal wetlands are important habitats that affect the quality of our lives and are indeed worthy of our concern, care, and protection.

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Introduction

Examination of the information dealing with South Carolina's estuaries[1] shows that most of the studies of the fishes, shrimps and crabs of our state were done mainly in deep water from relatively large boats that towed nets on the channel bottoms. From these types of surveys, we know a great deal about the kinds of fishes, shrimps and crabs found in the deeper estuarine waters. We know how their abundance (number of individuals in a species) changes with the season in the deeper waters. From their changes in size through the year we can obtain a rough estimate of their growth. We also know how the various types of animals are distributed with respect to salinity[2]. Some animals are found in fresh water or low salinity waters only; others are found only in high salinity waters around the inlets; still others are able to live in waters that have a wide range of salinities, and are found throughout the estuary.

Although our understanding of the animals that live in our estuaries was increased by these studies, the characterization of the community of animals in these areas underestimated the importance of other habitats. These are the "living spaces" that are in the shallows. These "living spaces" are divided into five categories: (1) oyster bars; (2) intertidal marsh; (3) shallow tidal creeks; (4) intertidal creeks; and (5) shallow bays with their mud flats.

Oyster Reefs

Although the tidal range varies with location along the coast, a depth of six feet is probably a reasonable average for South Carolina. Anyone who has spent time on our coast knows the great abundance of intertidal and subtidal[3] oysters in the lower reaches (high and moderate salinity areas) of the estuaries. These reefs are composed of living oysters and shell rubble, cemented together by the living oysters, which form the substrate for the settlement and attachment of new, young, living oysters. The reef provides what biologists refer to as structure. The irregularities in the surface of the reef furnish many places for animals to hide. The numerous small fishes and invertebrates (animals without backbones such as crabs, sea worms, shrimps) attract predatory fishes such as spotted seatrout, red drum and sheepshead. In addition, the presence of structure modifies the tidal currents causing the water to form eddies, up-wellings and rips that concentrate small animals that in turn attract predators.

The living oysters aggregated on a reef serve several important functions in the estuary besides providing food for man. As previously mentioned, they provide structure and living spaces for small fishes and crustaceans. In states to our north and those south of Georgia, estuaries contain extensive seagrass beds[4]. These beds serve as protection for small fishes and crustaceans. They add structure[5] to the habitat. Our waters lack these grass beds and the oyster reefs have taken over the role of providing structure in the estuary. In addition to providing living space, oyster reefs stabilize banks; that is, their intertidal presence on a shoreline will help prevent the erosion of the bank by strong tidal currents and wave action.

Oyster Harvesting

Oysters are bivalves related to clams and mussels. Once they settle out of the water as larvae and attach to a hard substrate, they lose their ability to move. They are filter feeders; that is, they open their top shell slightly and pump water across their gills. The fine particles that are suspended in the water are trapped by mucus as they pass across the gills. The particles are then sorted with non-food items being expelled from the shell and the food ingested. Oysters feed on algae, which are microscopic plant-like organisms suspended in the water. After the food is digested and the nutrients absorbed, the feces are released providing a food source for other animals associated with the reef. When large numbers of oysters are found together on a reef or a series of bars, they can remove a considerable amount of material from the water as it is pumped through their shells. Thus, oysters can actually clarify the water.

In a study of fishes, shrimps and crabs associated with oysters found below the low tide mark in

the creeks behind Caper's Island, 32 species of fishes and 16 species of shrimps and crabs were collected over a one year period in trays filled with oyster shells. These animals moved into these shells to find food and protection. Some of the more important fish species, i.e., those sought by recreational and/or commercial fishermen, were gag grouper, gray snappers, sheepshead and mummichogs (mud minnows).

Gag grouper are highly sought by commercial and recreational fishermen along the southeastern coast of the United States. They spawn in off-shore waters during the late winter. The eggs float and hatch into larvae. The larvae drift with the currents and are finally transported into the lower reaches of the estuary (the high salinity areas) where they settle out in structured habitat like oyster reefs. They use the numerous spaces in the shells to hide from predators while feeding on many of the small shrimps and fishes associated with this oyster reef habitat. Groupers are warm water fishes. As the inshore waters cool in the fall, the gag grouper that are about 8 inches in length leave the estuary for the warmer waters of the nearshore "live bottom".[6] These reef areas provide places to hide and are home to other animals that are eaten by groupers. Gag grouper may live longer than 20 years and attain a weight of over 50 pounds. Historically, this species made up an important part of the commercial landings. It is also an important recreational species. Anglers who either chartered boats for bottom fishing on these reefs or paid for passage on a head boat[7] caught significant numbers of these groupers. It was a successful trip when you returned to port with a twenty pound gag grouper.

Sheepshead are a very important species landed by recreational anglers. They spawn off-shore during the late winter and very early spring. The eggs hatch and the larvae make their way inshore by riding the various currents. They enter the estuaries and settle out of the water and take up residence in those places where there is structure. Inshore, these are the areas around oyster bars, wrecks, jetties and groins. There they find protection from predators as well as an abundant supply of crustaceans such as small shrimps, crabs and barnacles. After they grow, they move about the estuary feeding on the many shrimps and crabs associated with the structured habitats. When the inshore waters cool in the late fall, many move to warmer off-shore waters around the artificial reefs and those "live bottom" reefs found in depths less than 90 feet. When the inshore waters warm the following spring, many of them move back into the high salinity parts of the state's estuaries.

Blue and stone crabs are among the important crustaceans found associated with oyster reefs. Small blue crabs also use these areas for protection and food. Stone crabs dig burrows around or under the reef. The larger stone crabs actually use their powerful claws to open and feed on oysters. Blue crabs are harvested by both commercial and recreational fishermen, whereas a single claw is taken from the stone crab by commercial fishermen for sale.

These are just a sample of the "important" fishes and crabs associated with oyster reefs. There are many other species that serve major roles in the community of animals living in this habitat.

Intertidal Marsh

Our state has more marsh acreage than any other state along the east coast of the U.S. The most recent available figure is an area of 344,500 acres or about 538 square miles. Examples of this habitat can be found in the large unbroken stretches of marsh grass at Cape Romain, in the ACE Basin, and between Fort Sumter and Folly Island . Salt marshes are where the land meets the water. This habitat is among the most productive on earth. As such it provides a significant source of energy to the estuary and nearshore waters. In addition, when flooded by tide, the salt marsh provides a protected area to numerous fishes and other estuarine animals.

The most obvious feature of the salt marsh is the dense growth of cordgrass. In South Carolina, the intertidal marsh (often called the low marsh zone) is the area of the marsh surface flooded twice each day at high tide. When we have excessively high tides around the new and the full moon, more of the marsh is flooded and the depth of water on top of the marsh is greater.[8] The portion of the salt marsh that is flooded by these higher than average tides is called the high marsh. The latter forms the transition area between the low marsh and the uplands.

The smooth cordgrass of the intertidal marsh comes in two forms: the tall form which is found along the edge of creek banks and can reach a height of nine feet and the short form which grows on the interior parts of the marsh and reaches a height of two to three feet. The grass has an annual cycle much like most other plants in our state. In the spring and summer, the smooth cordgrass grows in height and is a rich green color. The leaves of the grass begins to turn brown and die back in the fall. The annual death of the leaves produces a rich organic material that supports many of the microorganisms (decomposers) that

Smooth cordgrass marsh (Spartina alternaflora)

play a critical role in the food chain.[9] Decomposers produce the "compost" of the marsh which is a source of food for other organisms. The dead and decomposing leaves are also exported from the marsh by the tides into deeper parts of the estuary and the nearshore coastal waters in the ocean.

The mud and sand found between the roots of the smooth cordgrass on the intertidal marsh harbors numerous small animals collectively called infauna.[10] These animals include sea worms, small crustaceans (animals that are related to crabs and shrimp), snails, and others. Many of these feed on the detritus that is covered with decomposers found on the marsh surface. One conspicuous animal of the intertidal marsh surface that is familiar to everyone is the fiddler crab. These small crabs make burrows in the areas of the marsh surface where the mud is firmer. They chose these areas because when they dig in places where the sediment is very soft, the burrows merely cave in after they dig them. At low tide, you can see these small animals scurrying across these firmer areas of the marsh. Often you can observe the males with their one large claw going

through their displays where they threaten off intruders. They feed on very small organisms and detritus found in the surface layers of the mud. When the incoming tide re-floods the surface of the marsh, the fiddler crabs go back into their burrows for protection until the next low tide.

Careful observation of the marsh surface at low tide shows that there are numerous water-filled potholes that contain small fishes. These small fishes are either mummichogs (mud minnows) or their very close relatives. They feed on small worms and crustaceans on the marsh surface, and by remaining in the potholes during low tide, they avoid the large predators that are found in the shallows adjacent to the intertidal marsh.

Animals adopt strategies to avoid being eaten. These in turn are countered by behavioral adjustments of the predators and so on. The process is very similar to the arms race that was conducted between the U.S. and the former Soviet Union. New offensive weapons were countered by new defensive weapons that were countered with adjustments to overcome these and so on. If animals fail to make these changes in their lives to avoid being eaten, eventually they will become extinct. One should be aware, however, that this process takes long periods of time relative to the life span of man.

As the tide floods the surface of the marsh, fiddler crabs return to their burrows. When there is sufficient water on the marsh for them to swim, red drum (also referred to as spottail bass or channel bass) move up onto the surface where they spend the high tide. These are subadult red drum that are from 8 to 30 inches in length and range from almost one to about four years of age.[11] They remain on the marsh surface until the tide ebbs to the point when there is not enough water to swim there. They then spend the period when the marsh is not flooded in the shallows adjacent to the large expanses of cordgrass.

What do these fish do during their stay on the flooded marsh? The answer to that depends upon the season. In spring, summer and fall when the red drum are actively feeding and growing, they use the flooded marsh as a feeding area. Although they will consume some small fishes like mud minnows and striped mullet on the flooded marsh, analysis of their stomachs shows that they are packed with fiddler crabs. At high tide when the fiddler crabs have supposedly returned to their protective burrows, red drum somehow manage to move them from their safety dens into their gut. If you pole a canoe or a small boat across the intertidal grass at high tide, you may frequently observe red drum tailing. That is, the fish are almost perpendicular to the surface of the marsh with their tails out of the water, flailing in the air. What are they doing? The red drum are removing fiddler crabs from their burrows and feeding on them. Thus an animal that constructs burrows to escape predators is countered by the behavior of the predator which has overcome the obstacle of the burrow in its pursuit of a meal.

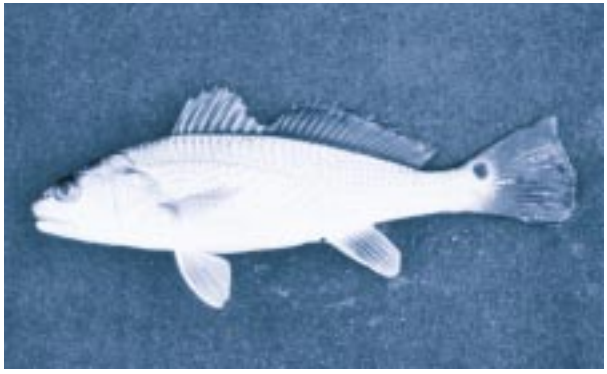
Shorebirds feeding on the exposed mudflats at low tide.

Red drum are cold-blooded animals. Their body temperature is about the same as the water in which they live. When the temperature gets low, these fish become sluggish. They are less active, do not feed as much, and during this season, they grow very little. Still the subadult red drum use the surface of the marsh. During the winter months there are fewer fish in the estuary than in other seasons. Many of these seasonal residents have either moved south to warmer waters or have gone off-shore to spawn. The largest predators, however, have not left the estuary. These are the porpoises, the major one being the bottlenose dolphin.

Stone crab (Menippe mercenaria)

Immature red drum over-winter in the shallow areas of the estuary. As the tide floods and the marsh once again becomes flooded, the fish move onto to its surface among the vegetation. As the tide ebbs, fish leave the vegetation but remain in the shallow water. They spend their time there until the tide re-floods the marsh surface. Around low tide, dolphins move into the shallows; however, they cannot get to the red drum. If a red drum makes an error and swims into water deep enough to allow a dolphin to move in, it probably will be the last mistake that fish will make as the mammal will make that fish its dinner. This is especially true at night when the fish have reduced vision and the dolphins can use their sonar. Without the flooded smooth cordgrass marshes, predation on red drum would be much greater during winter months. The population size of red drum would no doubt decrease, and there would be fewer fish available for recreational anglers.

Other fishes are also found on the high marsh at high tide. For example, some young spot move onto its surface as the tide floods. They graze on the sea worms and small shrimp and crab-like animals found in the mud. As the tide ebbs, they move off into the shallows. The tidal flooding of the marsh surface gives spot the chance to feed with a minimum risk of being eaten since the grass blades provide protection.



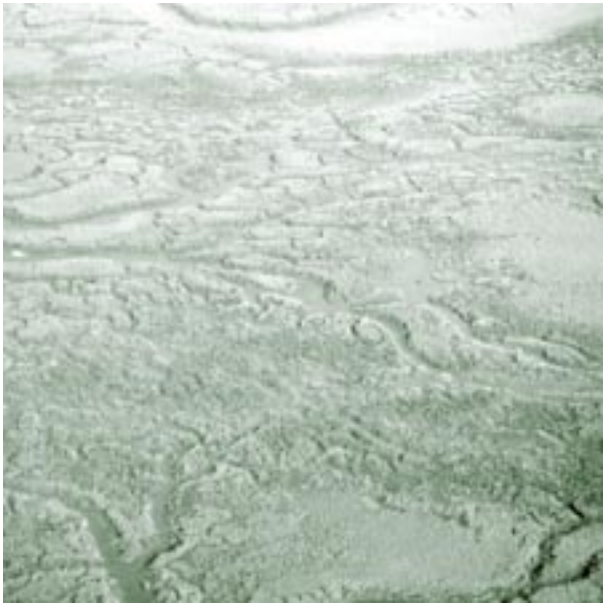
Red drum (Sciaenops ocellatus)

Shallow Tidal Creeks

The large expanses of South Carolina's smooth cordgrass marshes have tidal creeks of various sizes that cut through them. Some of these are above the low tide mark whereas others always have water in them although it may be but a few inches. Some of the most important of these tidal creeks are those small in size (a few yards in width) and subtidal (have water in them at all times).

At high tide more area is available to small fishes, shrimps, and crabs. These animals disperse to the various habitats that were unavailable to them at low tide such as the marsh, mud flats and oyster bars. However, as the tide ebbs, they move from these areas to the shallows. More often than not, they end up in the shallow tidal creeks. In South Carolina, the types of fishes found in these creeks at low tide vary with the salinity of the water. In the lower parts of the estuaries near the ocean, the amount of salt in the water is the greatest. Many of the fishes found there are from the nearshore environment. They are spawned offshore, carried into the estuaries by currents, and settle out in high salinity creeks. When they arrive in these creeks, many of them are less than a quarter of an inch in length. In these creeks and the contiguous marsh these fishes feed and grow. The shallows offers them an abundant food supply as well as a certain amount of protection from predators.

As one progresses further upriver, the salinity decreases. That is, more of the ocean water is diluted with the fresh water discharged into the system from land. In these shallow tidal creeks that are less salty, different fishes are found, and often they are much more numerous. There is a seasonality in the kinds of fishes that live in these creeks. The year is divided up into times when



Aerial view of tidal creeks throughout marsh

certain fishes use these shallow habitats as nursery grounds. For example, in late winter and early spring, we find juvenile spot, Atlantic croaker, striped mullet, Atlantic menhaden and southern flounder in shallow tidal creeks. As they grow, they begin to move out of the creeks into larger parts of the estuary. Spring and early summer brings spotted seatrout, bay anchovies, Atlantic silversides and others. In late summer and early fall, young red drum enter the creeks. In the late fall, only a few species of fishes are found in the creeks. Late winter brings a repeat of the previous year's cycle. These creeks are also home for the smallest stages of the white and brown shrimp.

Biologists refer to these creeks as primary nursery habitats. Contrary to the popular notion that these are the places where shrimps, crabs and fishes spawn, most of these animals reproduce down river near the inlets or well off-shore. The shallow tidal creeks are those habitats inside South Carolina's estuaries where the young juveniles of numerous species of fish and shellfish find a place where food is abundant and predators can be

avoided. Many move onto the intertidal mud flats with the flooding tide to feed. At high tide when predators can access these creeks, the juveniles are more widely spread out (diluted by more water in the estuary) and many are in the vegetation which serves as an excellent hiding place. As the tide ebbs and the predators are forced to leave the shallow creeks, the juveniles move back into the shallow creeks where they can be very abundant, sometimes reaching concentrations of more than 1,000 fish per square yard.

The species that are found in these creeks are the young stages of some of the most important fish and shellfish in the estuarine and coastal waters. Among those prized by recreational anglers are red drum, spotted seatrout, southern flounder, black drum, sheepshead, ladyfish, spot and Atlantic croaker. Young blue crabs are abundant in this habitat as well as the smaller white and brown shrimp. Other types of fishes are extremely important in an ecological sense. For example, they provide an important food source for predatory fishes. Examples of these are the striped mullet, bay anchovy, Atlantic silverside, mummichog (mud minnow) and Atlantic menhaden. Mummichogs, striped mullet and Atlantic menhaden are all exploited commercially. Mud minnows are caught with fine mesh baited traps and sold as bait. Striped mullet are heavily exploited in a fall fishery in North Carolina, mainly for the roe (developing ovaries) that are processed for the Japanese market. There is no commercial fishery for them in South Carolina, however recreational fishermen use them for bait and coastal residents frequently harvest them to smoke and/or use the roe for home consumption. A substantial purse seine fishery for Atlantic menhaden exists on the east coast of the U.S. from North Carolina through southern New England. The fish are processed for their meal which is used as poultry food and oil which is used as a base for margarine. In addition, this species is also a favorite bait of recreational anglers and entices a variety of large gamefish to bite a hook.

The remaining species (bay anchovy and Atlantic silversides) are important food items for species like spotted seatrout, southern flounder, Spanish mackerel, ladyfish and others.

Tidal creeks and expansive marsh

Intertidal Creeks

At low tide, along the edges of the marsh in both the main stem of the estuary and in the smallest tidal creeks, the intertidal creeks become exposed. These are basically cuts in the surface of the marsh. In many areas they resemble nothing more than gullies with a mud bottom. Because of the way that the marsh is constructed, as water enters the estuary with the flood tide, these intertidal creeks are some of the first areas to be covered with water.

Biologists have described these "muddy ditches in the marsh" as the corridors that small fishes and shrimps use to gain access to the vegetation on the more elevated portions of the marsh. Although some fish simply move over the edge of the marsh with the tide, more move up these small creeks as they become flooded. This serves as a way to avoid predators in two ways. First, the smallest fish and shrimp stay in very shallow water thus reducing the possibility of predation. Second, by using these intertidal creeks they gain access to the vegetation on the surface of the marsh which provides "cover" to reduce their visibility as they feed.

Some of the juvenile fishes that use these intertidal creeks are the southern flounder, red drum, spotted seatrout, striped mullet and spot. Brown and white shrimp use these as avenues to reach the vegetation. As the tide ebbs, these are the last places that become exposed, and the fishes and shrimps use them as corridors once again to move from the marsh to the shallows.

Shallow Bays with Their Mud Flats

The most visible examples of shallow bays and mud flats in the Charleston Harbor Special Management Area are those areas found near the Intracoastal Waterway north of the mouth of Charleston Harbor. These bays are found behind the barrier islands from Sullivan's Island to Bulls Bay, however, they are not limited to just those areas, i.e., they can be found all along the South Carolina coast. As you drive across the Isle of Palms Connector, these bays are west of the waterway. Directly below the bridge is Gray Bay which connects to Hamlin Sound and Copahee Sound. These are west of the Isle of Palms and Dewees Island.

These shallow bays are especially important during the winter months for subadult red drum that are from one to four years old. When water temperatures cool in the fall, red drum that were dispersed throughout the estuary and on the front beaches and nearshore bars move to these shallow

Gray Hamlin Copahee

bays where they overwinter. These shallows are refuges from the dolphins that are the main predators of red drum during the colder months of the year. The dolphins are warm blooded animals and are able to regulate their body temperatures during the coldest weather. Red drum, however, are not able to regulate their body temperature and take on the temperature of the water in which they live. Fishes have a range of temperatures where they are most comfortable and active. At these water temperatures the fish can swim efficiently, feed, migrate, and generally conduct their lives in the best fashion. When the temperatures decline and are not in this range, the fish are not as active. They are sluggish swimmers, stop or dramatically reduce feeding and are much more vulnerable to predators that can be active at those temperatures.

As previously mentioned, red drum are in the smooth cordgrass on the surface of the marsh at high tide, even in winter. As the tide drops, they move off the marsh and stay in the shallows of these bays where water may only be 6 to 12 inches deep. They also tend to be found around the tips of the oyster bars that are partially submerged. By staying in shallow water, they avoid the dolphins that are restricted to the deeper waters. The oyster bars provide an additional deterrent to the mammals moving into the shallows. The body of the animal would become lacerated by the force of its weight pushing down on the sharp edges of the shells. These shallow bays are extremely important to overwintering fish.

A very important fishery has developed in shallow bays during the cold months of the year. Boats that are able to float in what is called "skinny water" carry fishermen to these areas in the winter. The boats have platforms in the stern where the captain of the vessel stands. He or she uses a push pole to propel the boat through the water. As the boat moves through the shallows, the captain is constantly looking at the water searching for signs of a school of red drum. The school can be detected with the aid of polaroid glasses which cut down on the glare from the water's surface. Also, as the school moves, the silvery sides of the fish are sometimes visible, and since they are in such shallow waters, their movements create ripples on the surface of the water which can be seen. Anglers stalk these fish in the shallows and cast baits to the school in an attempt to entice a fish to bite. The most popular type of equipment for this sport is fly fishing tackle. In very recent years, there has been an increase in the number of shallow water boats (flats boats[12]), fishing guides (shallow water charter boats and captains), sales of fly fishing and light fishing tackle and all the other supplies and equipment that goes along with this fishery. Expenditures by both tourists and local sportsman make a significant contribution to the local economy.

Fly-fishing from a flat boat in a shallow bay

Wasteland?

Are these five areas a wasteland that should be ditched and channelized, backfilled, bulkheaded and dredged, or are they of some use to man? There is a body of scientific evidence that demonstrates that these areas are extremely important to man. Although the beauty of these areas is readily apparent to anyone who has watched the sun set over the lush, expansive field of green smooth cordgrass, there are several very practical reasons for the protection of these habitats.

1. These shallow tidal creeks with their oyster bars, mud flats, intertidal creeks and marsh are the principal nursery area for fishes and shellfish in South Carolina. Numerous commercially and recreationally important species use these areas as the places where their larvae grow into juveniles before moving into other habitats in the estuary. Here they find food and protection from predators. If the critical balance among these areas is disturbed it will impact the recreational harvest of such species as spotted seatrout, red drum, white shrimp, and others. In addition, commercial fishermen will see impacts on brown shrimp, white shrimp, Atlantic menhaden and others.

2. When the shallows become inundated by the tides, numerous species of fishes move into these areas to feed on other fishes, shrimps and crabs. During the warmer months, red drum move onto the marsh surface to feed on fiddler crabs. Southern flounder move to the edges of the smooth cordgrass where they modify their color to blend in with the bottom and become almost invisible. There they ambush small fishes like striped mullet and mummichogs (mud minnows) as they swim along the edge of the vegetation. Spotted seatrout feed on these same fishes as well as shrimps as they patrol the edges of the flooded marsh. Other predators wait for the tide to ebb so that they might ambush shrimp and small fishes as they move down the intertidal creeks. Almost all fishermen realize the increased probability of catching a gamefish around the mouth of a creek as the tide drops.

Marsh habitat

3. The shallows provide an area where the risk of being eaten by a predator is greatly reduced. In winter, red drum use the whole shallow water system to avoid predation by dolphins. If a juvenile fish lives in an inch or two of water, it reduces the possibility of being eaten by a larger fish that can not swim in water that shallow. The potholes that remain filled with water at high tide provide a place where small fishes can avoid predation.

4. The whole marsh system acts as a biofilter by removing a number of substances from the water column as they pass through the system. Nutrients that are derived from the land are

taken up by the cordgrass and the other marsh vegetation.

5. The marsh acts as an important source of food materials for many of the estuarine organisms. The annual die-off of the cordgrass provides materials which can be used and broken down by fungi and bacteria. This nutrient-rich decomposed material or detritus is consumed as a food source by fish such as striped mullet and animals in the sediment such as sea worms. These are consumed by predators. A major source of the food that makes the estuarine system so productive is the intertidal marshes.

6. The shallows provides food for many other organisms. Examples are wading shore birds such as the Great Blue Heron and Snowy Egret. These birds wade in the shallows, moving from the intertidal marsh at high tide to the shallow tidal creeks at low tide. In both these areas, they wait with statuesque majesty until a small fish or shrimp comes within striking range and is eaten. Ospreys patrol the airspace over the shallow bays during the period around high tide. There these birds take aim at striped mullet that swim along the edges of the smooth cordgrass marsh. Raccoons search the shallows for crabs and other shellfish. Diamondback terrapins use the shallows for food and move into the areas that are rarely flooded to lay their eggs. These are just a few of the animals that use these areas.

These "living spaces" are not separate entities, but instead they are analogous to pieces of fabric of differing color and design that are sewn together to make a quilt. You can not have a functional blanket unless all the individual pieces of cloth are connected and intact. The same goes for the shallows. The people of South Carolina will not have a functioning shallow water habitat in the state's estuaries unless all of the pieces are healthy. No one part is more important than the other. They are all interrelated and their value is either eliminated or highly decreased when they are negatively impacted by man's activities.

The location of these areas or habitats makes them very susceptible to the possibility of being modified by the activities of man. This system is the transition area between the deep waters of the estuary with the high land used by man, and as such, is highly vulnerable to being impacted. Stormwater runoff from paved parking lots floods into drains that dump into the subtidal creeks that wind their way toward the low-lying land. This runoff carries the petroleum residues from our cars and roadways. In summer, the rapid addition of major amounts of water from afternoon thunderstorms can reduce dissolved oxygen in the creeks to sometimes lethal levels to fish and shellfish residing there. Additional stress is placed on these animals by the rapid dilution of the estuarine waters by freshwater resulting in a decline in the salt content.

In locations where houses and agricultural operations occur at the interface of the marsh and highland without a vegetative buffer (a setback from the marsh which is filled with vegetation), runoff will add agricultural pesticides and fertilizers as well as animal wastes to the marsh habitat. These same products will also be washed off the lawns of residences into the habitats that people pay so much money to live near. Docks constructed over broad expanses of marsh reduce the quality of the view and shade vegetation. One dock may not be a problem, however, it is merely a sign of increased activity by man in the area which, from an historical perspective, results in a general deterioration in the quality of the environment, here the marsh. These are just the more readily visible problems.

What Does the Future Hold?

The projections for coastal development show that there will be considerable growth in these areas. Along with the influx of people comes additional stresses to our estuarine resources, especially those that are in the closest contact with the development. More people = more sewerage; more sewerage = more nutrients and a greater demand on the oxygen in estuarine waters. More people = more boats; more boats = more traffic; more traffic = more erosion of the marsh at the interface of the shallows and the deeper waters. More boats = a greater demand for marinas; more marinas = more boat related pollution (heavy metals, petroleum, human waste). More people = more fishermen; more fishermen = an increase of the fishing pressure on our already heavily exploited resources. More people = more shoreline development; more shoreline development without adequate buffers = more runoff with fertilizers and pesticides. More people = more strip malls and paved parking lots; more of these = more runoff with the variety of residues that will end up in the marshes and shellfish.

Past unrestricted development of coastal areas in the United States has resulted in the deterioration of the resources that make coastal communities desirable places to live and work. Residents along Boston Harbor, New York Harbor, Chesapeake Bay, San Diego Bay and Tampa Bay can attest to this fact. However, it is not too late for coastal South Carolina to prevent the repetition of history, promote good stewardship and protect the resources of its estuaries.

Glossary

1. An estuary is a semi-enclosed body of water where the salt content of the oceanic water is diluted by the fresh water running off the land into the rivers; it is a zone of mixing of the fresh water of the river systems with the ocean waters.

2. Salinity is the amount of salts dissolved in the water; it is written as parts per thousand. Water with a salinity of 10 parts per thousand has ten units of salt in every thousand parts of solution.

3. Intertidal refers to that area of shoreline between the high and low tide points; subtidal refers to that bottom that is not exposed by the tides, i.e., below mean low water.

4. These beds are absent in South Carolina and Georgia because of the extreme tides which stirs up the sediment and clouds the water; these grasses need relatively clear water to grow.

5. Coral reefs, artificial reefs and oyster reefs provide food and shelter for numerous animals. As an analogy, compare the number of people in high rise apartments of urban areas with the density of people in farming country. The high rises provide more structure hence more spaces for people to live. The abundance of animals on sandy or muddy bottoms is much less than on the oyster reefs. These are the high rises in the estuaries.

6. At certain locations off the coast of the southeastern U.S., the sand that is found covering most of the bottom has been eroded away. This exposes the hard limestone rocks which provide a substrate for corals and sponges to attach to the bottom. The growth of these invertebrates on the bottom provides structure which attracts numerous species of fishes.

7. A head boat is generally a relatively large vessel that takes numerous anglers for a days fishing for a fixed fee. You pay a fixed fee regardless of the number of other passengers on board, hence the name head boat.

8. This also happens when we have a strong onshore wind from the east or northeast. Winds from this direction tend to push more water from the ocean into the estuary with the incoming tide.

9. The first step in the food chain is the producers. Most of these are plants that use sunlight, water and carbon dioxide from the air in the presence of the green pigment, chlorophyll, to produce sugars and carbohydrates. Herbivores consume the living plants; carnivores eat the herbivores; omnivores eat both plants and animals. The microorganisms (bacteria and fungi) feed on the dead plant material and change it into detritus that can be used as an energy source by animals. They recycle the dead plant material.

10. Infauna refers to animals (=fauna) that live in the sediments on the bottom like clams, sea worms, some snails, some crustaceans, and so on. Epifauna refers to animals that live on the surface of some object. For example, barnacles growing on a rock are epifauna.

11. Subadult red drum are those that have not as yet reached sexual maturity.

12. Flat boats originated in the Florida Keys where many of the gamefish live on expansive shallow water flats that would not be accessible to ordinary boats. Since fish are very 'spooky' in shallow water, poling platforms were added to make it easier to push the boat and to see fish.

ACKNOWLEDGMENTS

This Charleston Harbor Project (CHP) publication is funded by a federal grant from the National Oceanic & Atmospheric Administration, Grant # NA77OZ0124.

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The CHP is a Special Area Management Plan (SAMP) for the Charleston, South Carolina, metropolitan area. The CHP overall objective is to provide community leaders and managers with adequate information to ensure decisions are made which assimilate the rapid population growth while maintaining the rich economic, cultural and natural history of the area. The CHP is sponsored by the National Oceanographic and Atmospheric Administration Office of Coastal Resource Management (NOAA/OCRM) and is administered locally through the South Carolina Department of Health and Environmental Control's Office of Ocean and Coastal Resource Manangement (SCDHEC/OCRM). For questions about this booklet/brochure or for additional information on the Charleston Harbor Project please call (843) 744-5838.

South Carolina Department of Health
and Environmental Control