Chapter Three

Habitats of the Estuarine Reserve

Cannonball jellyfish

Starfish

Mole crab

Coquina clam

Ocean Beaches

The ocean beach that sunbathers love is only one part of the ocean beach habitats found at the Reserve sites. The beach in a sense begins underwater, extending in some places for miles offshore to the edge of the continental shelf. The water currents and patterns of sediment deposition along the shelf influence what a beach looks like – how it erodes, its size. Along the shore itself are three contrasting environments – the subtidal, intertidal and supratidal zones – which are populated by organisms specially adapted to the harsh characteristics of each area.

Subtidal zone

The shallow waters, breaking waves, and swirling sand of the subtidal zone are home to plankton, algae, jellyfish, starfish, mollusks, crustaceans and fish. The only plants that survive here are one-celled algae. The constant movement of water and sand prevents organisms that need to be attached to a hard surface (such as barnacles) from taking hold. As the water rakes shell fragments and coarse sand across the bottom, each wave can injure or bury organisms.

Great Southern White

Intertidal zone

Animals living in the sandy environment of the intertidal zone are exposed to alternating periods of wave action and salt- laden drying breezes. Although it may appear that the only creatures here are birds, millions of tiny worms, shrimp and other organisms live among the sand grains. Coquina clams, *Donax* spp., and mole crabs, *Emerita talpoida*, survive by burrowing into the sand and filtering plankton (microscopic plants and animals) from the waves that wash over them.

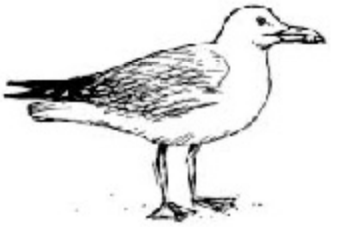
Quiick escape into the sand is essential to avoid being eaten by the groups of sandpipers, *Caladris* spp., andother shorebirds patrolling the beach. Scavenger birds like the herring gull, *larus argentatus,* are common and feed on dead fish, mollusks and crustaceans.

Supratidal zone

The supratidal beach zone – above the high tide mark – is a desert-like environment except during storm tides. Plants that occasionally grow in this zone at the Reserve sites are the sea rocket, *Cakile* spp., and sea oats, *Uniola paniculata.* They may be found along the drift line where bits of organic matter and debris in the soil make it possible for the plants to grow.

Sand shrimp

Brown pelican



Herring gull

Sea rocket

Laughing gull

Prickley pear

Ghost crab

Raccoon

The scavenging ghost crab, *Ocypode albicans*, makes deep tunnels with front and back entrances to avoid predators and the high temperatures of the upper beach, but must daily wet its gills in the ocean. The beach flea, *Talorchestia* spp., survives the harsh conditions by hiding in burrows or debris and feeds on dead plant and animal material.

At night during the summer, female loggerhead sea turtles, *Caretta caretta*, a federally protected threatened species, come from the ocean and nest in the upper beach on Masonboro Island, Zeke's sand spit and occasionally at Currituck Beach. In late summer and fall, the emerging baby turtles must dig out of their nests and make a short yet perilous journey to the sea, avoiding predators such as ghost crabs, birds and raccoons. The female turtles that survive will eventually return to the same area for nesting.

Sand Dunes

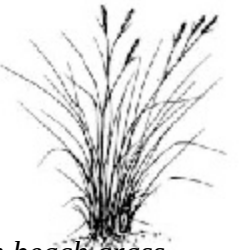
Sand dunes are a critical part of the coastal ecosystem. They protect the individual barrier islands from the wind, waves and storms, much as the islands protect the mainland. On islands where extensive dune systems are able to establish, complex communities like the shrub thicket and maritime forest can grow sheltered from salty winds. Salt marshes can develop along the protected shoreline.

Sand Dunes

Dunes also protect buildings and beach cottages, an important fact for people who enjoy vacationing or living at the beach. Natural dunes occur on the ocean side of Zeke's Island, Masonboro Island and the Currituck Banks sites. The Rachel Carson site contains small dunes on Bird Shoal.

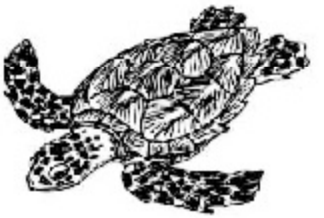
Sea oats, *Uniola paniculata*, and American beach grass, *Ammophila breviligulata*, are primarily responsible for creating the dunes. Sea oats occur throughout the mid-Atlantic area. American beach grass is native to the coast north of Cape Hatteras, although it does grow in some areas of the southern coast. Both plants are uniquely adapted to the harsh environment of salt-laden winds, shifting sands, poor soil and glaring sun. The grasses' roots and underground stems – which can extend as much as 30 feet below the surface of the dune to reach water – form a network that holds mounds of sand together. As more grasses stabilize the sand, a dune line is established.

These plants have flexible leaves that can withstand being whipped about by the wind. A waxy coating on each leaf conserves water, which is essential for survival on this desert-like environment. The roots have to absorb moisture efficiently because the porous sands hold virtually no water. Salt spray, the plants' primary source of nutrients, is absorbed either from the soil or the plant surface.



American beach grass

Ring-billed gull



Loggerhead turtle

Atlantic bottle-nose dolphin

Sand Dunes

Panic grass

Croton

Beach flea

Black skimmer

Other dune plants include sea elder, *Iva imbricata*, sea rocket, *Calike* spp., croton, *Croton punctatus*, sand primrose, *Oenothera humifusa*, panic grass, *Panicum amarum*, and sea spurge, *Euphorbia polygonifolia*. Although these species are not the colonizers that sea oats and American beach grass are, they have adapted to the dune environment with flexible, waxy leaves and stems, like those of the sea elder and sea rocket, or by growing flat on the ground, like the sea spurge and trailing sand primrose.

There are few animals in the frontal dunes, all of which also forage in the upper beach. Many of these organisms are insects – digger wasp, *Bembex* sp., velvet ant, *Dasymutilla* sp., earwig, *Anislabis* sp., and mole cricket, *Gryllotalpa hexadactyla* – which are adept at digging or hiding under debris for protection. The digger wasp cools itself during its excavating efforts by periodically flying up from baking sediments.

Ghost crabs and beach fleas are upper beach residents that also forage in the dunes. Storm-overwash areas – where the dunes have been breached and fresh deposits of sand blanket the vegetation – are prime habitats for ground nesting birds such as the black skimmer, *Rhynchops niger*, Wilson's plover, *Charadrius wilsonia*, common tern, *Sterna hirundo*, and least tern, *Strerna alsifrons*.

Grasslands

Behind the dunes, protected from the salty winds and waves of the ocean, are grasslands. A greater diversity of species can survive in this milder environment.

Sea oats, *Uniola paniculata*, or American beachgrass, *Ammophila breviligulata*, which dominate the frontal dunes, share this habitat with salt meadow cordgrass, *Spartina patens*, broom sedge, *Andropogon virginicus*, panic grass, *panicum* spp., and sandspur, *Cenchrus* spp. Other plants found here include seaside goldenrod, *Solidago sempervirens*, gaillardia, *Gaillardia pulchella*, yucca, *Yucca filamentosa*, sand primrose, *Oenethera humifusa*, Drummond's prickly pear cactus, *Opuntia drummondii*, camphorweed, *Heteratheca axillaris*, pennywort, *Hydrocotyle bonariensis*, and beach morning glory, *Ipomea* spp.

Vines, shrubs and small trees grow in the back dunes where direct salt spray is reduced, often marking a gradual transition to the shrub thicket community. Catbrier, *Smilax* spp., Spanish bayonet, *Yucca* spp., yaupon, *Ilex vomitoria*, Hercules' club, *Zanthoxylum clava-herculis*, live oak, *Quercus virginiana*, and red cedar, *Juniperus virginiana*, are examples of shrub thicket species occasionally found in grassland areas.

Broom sedge

Seaside goldenrod

Hercule's club

Shrub Thickets

Meadow mouse

Six-lined racerunner

Virginia creeper

Boat-tail grackle

Grassland animals that move between the dunes and shrub thicket/maritime forest include the house mouse, *Mus musculus*, meadow mouse, *Microtus pennsylvanicus*, cottontail rabbit, *Syvilagus floridanus*, eastern glass lizard, *Ophisaurus ventralis*, corn snake, *Elaphe guttata*, and six-lined racerunner, *Enemidophorus sexlineatus*. At the Rachel Carson and Currituck sites, feral horses, *Equus caballus*, graze on upland and marsh grasses. These are domestic horses that have turned wild.

Various birds such as the red-winged blackbird, *Agelaius phoeniceus*, mockingbird, *Mimus polyglottos*, and boat–tailed grackle, *Quiscalus major*, forage in the grasslands for insects and seeds. Mourning doves, *Zenaida macroura*, ground doves, *Colunbina passerina*, and nighthawks, *Chordeiles minor*, nest and feed there as well.

Shrub Thickets

As distance from the ocean increases, the effects of salt spray and temperature variations from tidal changes are reduced, making it possible in some parts of the Reserve for shrub thicket to grow. This habitat typically consists of a dense mixture of vines, shrubs, and small trees. Depending on the level of exposure to sea breezes, the seaward edge of the thicket may be dramatically angled.

Shrub Thickets

When salt spray kills the terminal, or exposed, buds on the shrubs and small trees, they branch out to the sides. This creates a closely woven canopy that protects the interior plants from salt spray. Early settlers of the barrier islands discovered that the thickets and the maritime forests were the safest places to build their homes because of the shelter they provided from the sun, wind and storms. Shrub thicket is found at the Currituck Banks site and parts of the Rachel Carson and Zeke's Island sites. Isolated nooks of shrub thicket paralleling the dunes are also found on Masonboro Island.

Plants that often dominate the thicket include live oak, *Quercus virginiana*, yaupon, *Ilex vomitoria*, wax myrtle, *Myrica cerifera*, silverling, *Baccharis halimifolia*, red cedar, *Juniperus virginiana*, persimmon, *Diospyros virginiana*, and at Currituck Banks, bayberry, *Myrica pennsylvanica.*

Growing over and through the shrubs and small trees are vines such as the Catbrier, *Smilax* spp., Virginia creeper, *Parthenocissus quinquefolia*, muscadine grape, *Vitis rotundifolia*, pepper vine, *Ampelopsis arborea*, and poison ivy, *Rhus radicans*. Where light can penetrate the canopy, there are patches of herbs containing partridge berry, *Mitchella repens*, panic grass, *Panicum* spp., elephant's foot, *Elephantopus nudatus*, pepper grass, *Lepidium virginicum*, and beggars ticks, *Bidens* spp..

Yaupon

Wax myrtle

Yellow-rumped warbler

Poison ivy

Opossum

Red-bellied woodpecker

Cotton mouse

Painted bunting

The vegetation in this community provides many niches for animal habitation. White-tailed deer, *Odocoileus virginianus*, are found at Currituck Banks, while raccoon, *Procyon loto*, opossum, *Didelphus virginicus*, cottontail rabbit, *Sylvilagus floridanus*, gray fox, *Urocyon coneroargenteus*, cotton mouse, *Peromyseas gossypinus*, least shrew, *Cryptotis parva*, and meadow mouse, *Microtus pennsylvanica*, are typical inhabitants of all Reserve sites.

Birds nesting on the dense vegetation include the painted bunting, *Passerina ciris*, catbird, *Dumetella carolinensis*, mockingbird, *Mimus polyglottos*, cardinal, *Richmondena cardinalis*, and Carolina wren, *Thryothorus ludovicianus*. There are also numerous warblers, *Dendroica* spp., and sparrows, *Melospiza* spp., and *Spizella pusilla*. Typical woodland reptiles of the Reserve are the six-lined racerunner, *Enemidophorus sexlineatus*, rough green snake, *Opheadrys aestivus*, corn snake, *Elaphe guttata*, and yellow rat snake, *Elaphe obsoleta.*

Maritime Forests

One of the most impressive barrier island plant communities is the maritime forest. The forests have adapted to seaside conditions to become the most stable, least changing habitat on the islands.

These characteristics make maritime forests important for preventing soil erosion, protecting against storm damage, preserving groundwater and providing habitat for plants, wildlife and humans alike.

Although each maritime forest developed differently, in many places it is believed that forests followed a pattern called "succession." This is a lengthy process that occurs where simple plant communities, like grasslands, develop into more complex communities. Shrub thicket areas may gradually develop into forest if salt spray, flooding, fire or storm damage do not alter the gradual overtopping of shrubs by trees.

This trend may be observed on North Island of the Zeke's Island site, on the east end of Carrot Island, throughout the Kitty Hawk, Buxton and Bald Head Woods Coastal Reserve sites and throughout the more extensive forested areas of Currituck Banks.

Paradoxically, the characteristics that make a maritime forest a "climax" – or highly stable – plant community also make it vulnerable to damage from storms, fires, and development. This is because forests take a long time to develop, and once damaged, do not recover easily.

Palamedes Swallowtail

Corn snake

Deer

Bayberry

Live Oak

Maritime Forests

Loblolly Pine

Black gum

Sweetgum

Eastern red cedar

Whereas grasses might reseed an area fairly quickly following a disturbance, the trees of a maritime forest require hundreds of years to establish. If the canopy is broken, allowing salt spray to reach vulnerable interior trees, a forest can be seriously damaged or destroyed. The forest on Shackleford Banks, part of the Cape Lookout National Seashore, is an example of this.

The primary distinction between shrub thicket and maritime forest is that in the forest the dominant trees, generally more than ten feet high, grow taller than shrubs and smaller trees like silverling, wax myrtle and yaupon. Also, there is less diversity (fewer woody plants) in this community.

Except for the effect of salt shear on the edges of the canopies, the dominant maritime trees may grow as tall as those of mainland forests, particularly on Carrot Island and Currituck Banks. The primary tree found in the forests is the live oak, *Quercus virginiana*. Other common trees include the loblolly pine, *Pinus taeda*, and the red cedar, *Juniperus virginiana*. Some hardwood species – red maple, *Acer rubrum*, sweetgum, *Liguidambar straciflua*, Carolina laurel cherry, *Prunus caroliniana*, and hackberry, *Celtis laevigata* – may also be found in the forest. The shrubs, herbs, mammals, birds, and reptiles found in the forest are essentially the same as those of the shrub thicket.

Coastal Marshes

Some of the most productive and valuable wetlands are coastal marshes. These marshes are regularly and irregularly flooded lands where specific plants grow depending on the tides, salinity levels and elevation. Four types of marshes are found within the Reserve sites: low salt, high salt, brackish and freshwater.

Salt marshes are found along the estuarine shorelines of the Zeke's Island, Masonboro Island and Rachel Carson sites. The wind-fluctuated, low salinity sound waters of the Currituck Banks site border brackish marshes. Freshwater marshes occur in depressions within the grassland, shrub thicket or maritime forest of all four sites.

Low Salt Marsh

The intertidal, or low, salt marsh is the foundation of the estuarine food web, and therefore is relied upon, directly or indirectly, by most organisms in the estuarine system. Fringing thousands of miles of estuarine shoreline in the state, this community is one of the most productive and self-sustaining habitats on earth.

The marshes are created as fine particles of silt and clay are deposited from slow-moving waters. The sediments are stabilized, much as sand dunes are, by a plant that is specially adapted to this harsh environment.

Glasswort

Saltmeadow hay

White ibis

Mud snail

Low Salt Marsh

Saltmarsh cordgrass

Speckled crab

Marsh periwinkle

Black needlerush

This key plant species is salt marsh cordgrass, *Spartina alternaflora*. This coarse grass can be from one to four feet tall, depending upon the elevation, and establishes an extensive network of roots and underground stems that bind the soft, sandy or muddy soil. Such an extensive "foundation" is necessary to maintain the grass colonies because there is no hard surface, or substrate, that the plants could attach to and avoid being washed away by the tides and wind-generated waves. Well-developed cordgrass stands actually protect the mainland from the effects of tides and waves by slowing the incoming waves and reducing soil erosion.

Salt marsh cordgrass has adapted to the dramatically changing salinities, fluctuating surface temperatures and changes in water levels by regulating salt and water concentrations in its cells and releasing excess water or salt through pores on grass blades.

Salt marsh cordgrass is one of the important producers in the estuarine food web. Each fall, the plant dies back and is washed into the estuary. There, bacteria break down the plant tissues into detritus, a primary food source for numerous aquatic animals, many of which are consumed in turn by other species. The detritus-rich estuarine waters also contain highly productive phytoplankton (microscopic plants) which further supplement the estuarine "soup" for the various consumers.

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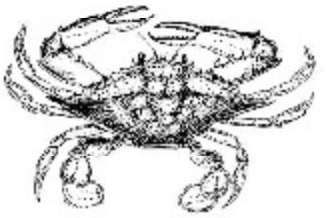
Low Salt Marsh

The intertidal marsh does contain other plant species, although cordgrass clearly is dominant. The upper intertidal zone typically has colonies of cordgrass of a smaller size with patches or zones of sea ox-eye, *Borrichia frutescens*, salt grass,D*istichlis spicata*, sea lavender, *Limonium carolinianum*, black needlerush, *Juncus roemerianus*, salt marsh cordgrass, *Spartina patens*, and in depressions(called pannes) where salt levels tend to be highest,glasswort, *Salicornia* spp.

Sea ox-eye



Blue crab

Animals of the intertidal marsh are either permanent residents or species from nearby habitats that forage in the marsh at different times of the day, depending on the water level. Marsh periwinkles, *Littorina irrorata*, are snails that graze on the microscopic algae growing on cord grass stalks. The snails climb up the stalks as the tide rises to avoid predators. Ribbed mussels, *Moliolus demissus*, attach to plant bases while oysters, *Crassostrea virginiana*, form colonies on any solid object. Both of these organisms are filter feeders, which means that they strain plankton, bacteria and detritus from the water for food.

Ribbed mussel

Found in large numbers on muddy sediments, the mud snails, *Ilyanassa obsoleta*, are generally scavengers for food on the marsh surface.

Sea lavender

Low Salt Marsh

Sand fiddler crab

Clapper rail

Great blue heron

Marsh fiddler crabs, *Uca pugnax*, burrow during low tide by scraping organic matter from the surface. Male crabs are distinguished by having one large claw and one small one while females have two small claws.

The diamondback terrapin, *Malaclemys terrapin*, is a turtle that lives in stands of cord grass and eats dead fish, live crabs and small mollusks.

Birds that nest in the upper intertidal marsh include the clapper rail, *Rallus longirostris*, marsh wren, *Cistothorus palustris*, and least bittern, *Ixobrychus exilis*. Myriads of gnats, flies and mosquitoes are also part of the marsh food web.

Numerous birds and mammals forage in the salt marsh during low tide. The American egret, *Casmerodius albus*, great blue heron, *Ardea herodias*, tricolored heron, *Hydranassa tricolor*, black-crowned night heron, *Nycticorax nycticorax*, willet, *Catoptrophorus semipalmatus*, boat-tailed grackle, *Quiscalus major*, black skimmer, *Rhynchops niger*, American oystercatcher, *Haematopus palliatus*, and osprey, *Pandion haliaetus*, are only some of the birds dependent upon the bountiful marsh food production.

Typical mammals regularly visiting the intertidal marsh include the raccoon, *Procyon lotor*, river otter, *Lutra canadensis*, meadow mouse, *Microtus pennsylvanicus*, red bat, *Lasiurus borealis*, Seminole bat, *Lasiurus seminolus*, and marsh rice bat, *Oryzomys palustris*.

High Salt Marsh

Supratidal, or high, salt marsh is only flooded by storm tides or extremely high spring tides. The daily flooding of the intertidal marsh gradually increases the soil elevation by deposition of fine sediments. As the land level increases, intertidal flooding shifts toward the sound and the supratidal zone follows. As a result of this process, supratidal species will move into former intertidal lands.

The upland edge of the supratidal zone will, in turn, gradually be invaded by shrubs. This general trend, however, is influenced by variations in inlet formation, storm erosion and deposition of overwash sediments along the coast.

Saltmarsh Skipper

River otter

Sea beach amaranth

Marsh mallow

Dune spurge

Brackish Marsh

Salt meadow hay

Cardinal

Red bay

Sedge wren

Above the daily tidal limits there is a gradual change in plant dominance from salt marsh cordgrass to a mosaic of salt meadow cordgrass, salt grass, sea ox-eye, black needle rush and glasswort, with fewer occurrences of sea lavender, salt marsh aster, *Aster tenuifolius*, and sabatia, *Sabatia stellaris*.

Considerably fewer animals use the supratidal than use the intertidal marsh zone. Insect-seeking birds such as the red-winged blackbird, *Agelaius phoneceus*, meadowlark, *Sturnella magna*, and seaside sparrow, *Ammospiza maritima*, regularly forage and nest in the high marsh. Other common animals include the meadow mouse, marsh crab, *Sesarma reticulata*, sand fiddler crab, *Uca pugilator*, and various insects such as the dragonfly, *Erythrodiplax berenice*.

Brackish Marsh

At the Currituck Banks site brackish marshes fringe the edge of the sound 45 miles from the nearest source of salt water – Oregon Inlet in Dare County. Currituck Sound receives freshwater from a number of creeks draining the mainland, plus irregular amounts of salt water from the inlet. The resulting sound water is classified as brackish, rarely exceeding two parts of salt per thousand parts of water, compared with 35 parts per thousand in ocean water.

Brackish Marsh

These waters are not influenced by regular lunar tides but by wind. This creates considerably different influences than those described under the tidal and supratidal marshes.

Dense colonies of giant cord grass, *Spartina cynosuroides*, spike rush, *Eleocharis obtusa*, black needle rush and cattail, *Typha* spp., dominate the Currituck marshes. Other associates include duck potato, *Sagittaria falcate*, sabatia, *Sabitia dodecandra*, bulrushes, *Scirpus* spp., and marsh mallows, *Hybiscus moscheutos* and *Kosteletskya virginica*. Transition to upland vegetation is characterized by a shrub marsh composed primarily of marsh elder and wax myrtle. Hempweed, *Mikania scadnes*, is a vine in the aster family, which occurs sporadically throughout the marsh.

These marshes serve as important nesting and foraging grounds for numerous species. Typical birds include the great blue heron, American egret, eastern green heron, *Butorides straitus*, snowy egret, *Egretta thula*, red-winged blackbird and numerous ocean seabirds such as gulls and sandpipers. Mammals regularly feeding in the area include the raccoon, marsh rabbit, *Sylvilagus palustris*, and white-tailed deer, *Odocoileus virginianus*.

Giant Swallowtail

Cattail

Giant cordgrass

Duck potato

Marsh rabbit

Freshwater Marsh

Pickerel weed

Bulrush

Marsh elder

Reed

Depressions within the grassland, shrub thicket or maritime forest communities may contain permanent to seasonally flooded ponds vegetated to varying degrees by marsh plants. The depressions within the Reserve are interdunal swales originally created by wind and water working and reworking deposited sediments. Where low spots intersect with the water table, a pond is formed. Low spots just above the water table hold rainwater and runoff until they evaporate. The best-developed freshwater marshes of the Reserve are found at the Currituck Banks site, while the other three sites contain isolated seasonally wet areas.

At Currituck Banks typical plants in the ponds include cattail, *Typha angustifolia* and *T. latifolia*, bulrushes, duck potato and pickerel weed, *Pontederia cordata*, mixed with patches of water pennywort, *hydrocotyle umbella*, bacopa, bacopa monnieri, marsh fleabane, *Pluchea purpurascens*, lippia, *Lippia lanceolata*, and diodia, *Diodia virginiana*.

Seasonal marshes at the other Reserve sites contain many of these species, often mixed with invading shrubs such as wax myrtle, silverling, marsh elder and willow, Salix spp. These marshes also serve as reservoirs for plants not typically found within the neighboring habitats.

Freshwater marshes within the Reserve sites are vital water sources for the upland animals. Mammals, birds and reptiles from nearby habitats regularly visit these "watering holes." The feral horses of the Rachel Carson site dig down to fresh water when the ponds are dry. Amphibians, such as toads, *Bufo spp.*, and various insects – flies and mosquitoes – require these freshwater areas as well.

Tidal Flats

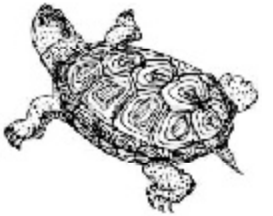
Low salt marshes are often bordered by mud and sand flats, which, although seemingly barren, are nevertheless an important part of the estuarine system. The flats are easily seen at low tide when, in some places, they stretch for several hundred yards. Tidal flats are found at the Zeke's Island, Masonboro Island and, especially, the Rachel Carson site of the Reserve. Many organisms feed on the flats, for this is where the broken down marsh grasses are carried.

The flats are formed by the deposition of various types of sediments – sand, silt or clay, depending upon local currents. The finer textured sediments settle with lower water velocities, while heavier sands are found where currents are stronger. Ebb and flow tides, however, typically mix the sediments to varying degrees and prevent the flats from drying out.

Tidal Flats

Feral horse

Diamondback terrapin



Southern toad

Eastern box turtle

Tidal Flats

Bloodworm

Lugworm

Atlantic jacknife clam

Northern quahog clam

The estuarine water associated with the flats varies in its chemical and physical properties during each tidal cycle and throughout the year. Water temperatures change with the tides; in summer the sun heats the exposed sediments during low tide, while the rising tide brings cooler water. This process is just the opposite in winter when the air is cooler and the water warmer. Salinities in isolated pools will increase with evaporation, but heavy rains or river inflow will decrease these concentrations.

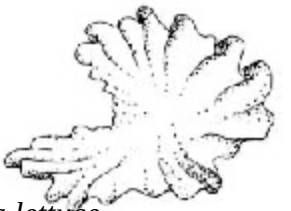
Regular tidal flows of ocean water further modify the water chemistry. Dissolved oxygen, which is vital to most aquatic organisms, is often plentiful in the tidal water, although sustained high temperatures in shallow water deplete the oxygen concentration. Muddy sediments usually have very low oxygen concentrations as indicated by the smell of "rotten eggs" (hydrogen sulfide gas).

Organisms permanently living in this habitat must be adapted to the many environmental fluctuations mentioned above. Burrowing worms, such as the blood worm, *Glycera* spp., lugworm, *Arenicola* spp., and clam worm, *Nereis* spp., find protection in the sediments, while many polychaete worms form permanent burrows or tubes, including the plumed worm, *Diopatra* sp., and parchment tube worm, *Chaetopterus* sp.

The quahog clam, *Mercenaria mercenaria*, and marsh razor clam, *Tagelus* spp., burrow with "feet"

and extend siphons into the water above the flat to draw in water, detritus and plankton. Most of the organisms move either into the sediments or out to sub tidal waters during the low tide. Two that do not are the filter-feeding oyster, *Crassostrea virginica*, and scavenging mud snail, *Ilyanassa obsoleta.* Young, mobile oysters attach to any hard surface, often other oyster shells, to form extensive colonies. The muddy sediments also team with anaerobic bacteria that are essential to the process of decomposing dead organic matter so that it can become part of the food web.

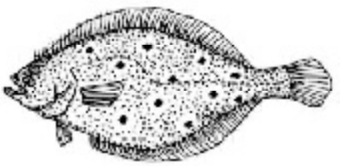
Transient organisms from the sub tidal zone are abundant when rising and high tides cover the flats. The primary plants are algae, ranging from unicellular mud algae and phytoplankton, to green, brown and red seaweeds such as sea lettuce, *Ulva lactuca*, dicyota, *Dictyota* spp., and sewing thread seaweed, *Gracilaria* spp., which float in the shallow waters and often become stranded on the substrate at low tide. Numerous small fishes and crustaceans, which seek the protection of the shallow waters, are killifish, *Fundulus* spp., silversides, *Menidia menidia*, pipe-fish, *Sygnathus* spp., filefish, *Monocanthus hispidus*, flounder, *Paralichthys* spp., pinfish, *Lagodon rhomboides*, shrimp, *Penaeus* spp., spider crab, *Libinia* spp., and blue crab, *Callinectes sapidus.* Jellyfish occasionally drift into the flats, including moon jelly, *Aurelia aurita,* and cabbagehead, *Stomolophus meleagris.*



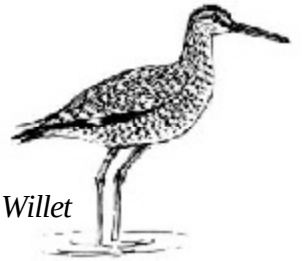
Sea lettuce

Peacock's tail

Atlantic silverside



Summer flounder



Willet

Dunlin

Dowitcher

Little blue heron

Terrestrial mammals and birds that forage extensively in the tidal flats, primarily during low tide, are the **raccoon,** *Procyon lotor,* great blue heron, *Ardea herodias*, willet, *Catoptrophorous semipalmatus,* clapper rail, *Rallus longirostris,* and American oystercatcher, *Haematopus palliates.* The black skimmer, *Rhynchops niger*, flies just above the surface of the water, capturing fish and crustaceans in its lower bill.

Subtidal Soft Bottoms

The bottoms of the sounds provide a habitat similar to that of the tidal flats, but one which is more stable because it is constantly underwater. Thus, the physical and chemical fluctuations of these areas are not as severe as they are in the flats. All four Reserve sites contain extensive sub tidal areas. Although most of this habitat is made up of mud and sand flats with occasional algae cover, in some areas flowering plants grow that are specially adapted to being underwater. These submerged aquatic beds are important to estuarine productivity. Beds of eelgrass, *Zostera marina,* are found at Rachel Carson site and Masonboro Island. Currituck Banks contains extensive submerged aquatic beds composed of species typical of low salinity sounds.

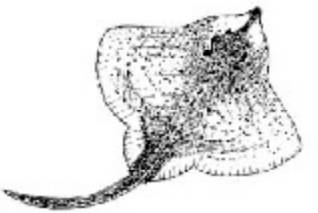
The open sub tidal bottoms of the Zeke's Island, Masonboro, and Rachel Carson sites are home to a wealth of fishes, mollusks, crustaceans, worms, jellyfish and other organisms. Many of the species

mentioned in the Intertidal Flats section are found below the low tide mark. Pinfish, *Lagodon rhomboides*, lookdown, *Selene vomer*, Atlantic silversides, *Menidia menidia*, mullet, *Mugil* spp., flounder, *Paralichthys* spp., pipefish, *Syngnathus* spp., spot, *Leiostomus xanthurus* and killifish, *Fundulus* spp., are some of the fishes common atthe sites. Deeper portions of the sub tidal areas are foraged by oceanic species such as the Atlantic bottlenose dolphin, *Tursiops truncatus*, a marine mammal found particularly around the Rachel Carson site, and large fishes including dogfish shark, *Mustelus canis*, stingray, *Dasyatis* sp., bluefish, *Ponatomus saltatrix*, and spotted seatrout, *Cynoscion nebulosus*.

Striped killifish

White mullet

Aside from the vertebrates listed above, there are other organisms in this community which scientists classify as Chordates – animals with at least a primitive type of spinal cord at some stage of development. Sea squirt, *Styela* spp., sea grape, *Molgula* spp., and sea pork, *Amaroucium* spp., are "glob-like" colonial organisms as adults and filter plankton from the water for food. Invertebrates, animals without backbones, are plentiful throughout the subtidal flats. Representative examples from various groups are listed below:



Clearnose skate

• **Crustaceans** (segmented organisms with hard outer skeletons that usually breathe through gills) – blue crab, *Callinectes sapidus*, and shrimp, *Penaeus* spp.

Sea squirt

Subtidal Soft Bottoms

Egg case
Channeled whelk

Parchment tube worm

Moon jelly

Dicyota

• **Mollusks** (unsegmented, soft-bodied animals with shells and feet) – whelk or conch, *Busycon* spp., quahog clam, *Mercenaria mercenaria,* and squid, *Lolliguncula brevis.*

• **Annelids** (worms and related organisms) – parchment tube worm, *Chaetopterus* sp., and lugworm, *Arenicola* sp.

• **Coelenterates** (soft animals with a central digestive cavity, the opening of which is ringed by stinging tentacles) – moon jelly, *Aurelia aurita,* cabbage head, *Stomolophus meleagris,* and sea whip, *Leptogorgia virgulata.*

• **Echinoderms** (spiny animals with tube feet) – sea cucumber, *Leptosynapta* sp., and sand dollar, *Mellita* sp.

• **Ctenophores** (gelatinous animals with rows of comb like plates) – comb jelly, *Mnemiopsis* sp.

• **Zooplankton** (microscopic animals) – unicellular organisms and larval stages of the groups mentioned above.

Algae can form dense colonies in sandy sub tidal areas, particularly where shells or other hard surfaces are available for attachment. Sporadic patches of green, red and brown algae occur at all the sites except Currituck Banks. Typical species include sea lettuce, *Ulva lactuca,* dead man's fingers, *Codium*

sp., dicyota, *Dictyota* spp., hypnea, *Hypnea* spp., and sewing thread seaweed, *Gracilaria* spp. Phytoplankton and bacteria are abundant throughout the water and on the surface of the bottom.

Submerged aquatic plant beds, often called "grass beds," occur within various salinity patterns at the Rachel Carson, Masonboro Island and Currituck Banks sites. Beds of eelgrass, *Zostera marina*, are scattered along Carrot Island and within Middle marshes of the Rachel Carson site, while isolated patches are found on the sound side of Masonboro Island. An economically important associate of this community is the bay scallop, *Aequipecten irradians*, a bivalve prized for its sweet-tasting meat. Numerous algae and microscopic animals live on the eelgrass leaves.

Extensive colonies of underwater plants cover the shallow mud and sand bottom of Currituck Sound. Dominant species include Eurasian water-milfoil, *Myriophyllum spicatum*, redhead grass, *Potamogeton perfoliatus*, pondweeds, *Najas* spp., wild celery, *Vallisneria americana*, widgeon grass, *Ruppia maritima*, and horned pondweed, *Zanichellia palustris*. Eurasian water-milfoil was introduced into Currituck Sound in 1965 and rapidly became dominant. Phytoplankton, in the form of diatoms, dinoflagellates and micro algae, are also abundant in the sound, particularly in winter when nitrogen levels are high.

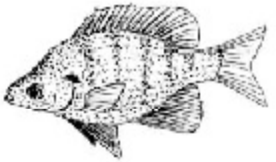
Hypenea

Eelgrass

Atlantic bay scallop

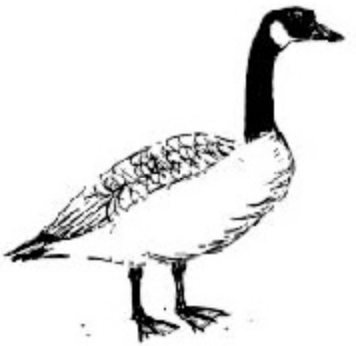
Eurasian water-milfoil

Largemouth bass



Bluegill

Hooded merganser



Canada goose

Animals associated with Currituck Sound's underwater plant beds and sediments are primarily bottom dwelling organisms and fishes. Organisms living in the sediments include amphipods, isopods, annelid worms, midge fly larvae and marsh clams, *Rangia cuneata.*

The low salinity levels are reflected by the presence of both freshwater and brackish species of fishes: largemouth bass, *Micropterus salmoides,* pumpkinseed, *Lepomis gibbosus,* bluegill, *Lepomis macrochirus,* white perch, *Morone americana,* catfish and bullhead, *Ictalurus* spp., and striped bass, *Morine saxatilis.*

Currituck Sound is famous as a migratory waterfowl stopover along the Atlantic Flyway. Ducks and geese that seasonally visit the estuary and feed on the aquatic plants include redheads, *Aytha americana,* pintails, *Anas acuta,* ruddy ducks, *Oxyura jamaicensis,* American wigeon, *Amas americana,* canvasbacks, *Athya valisineria,* buffleheads, *Bucephala abeola,* black ducks, *Anas rubripes,* ring-necked ducks, *Aytha collaris,* and Canada geese, *Branta canadensis.*

Dredge Spoil Areas

Both the Masonboro Island and the Rachel Carson sites contain areas that, over the past few decades,

Dredge Spoil Areas

have been used by the U.S. Army Corps of Engineers to dispose of spoil material from maintenance dredging of shipping channels. The Corps has permanent easements for deposition at the Reserve sites – at Masonboro Island along the Atlantic Intracoastal Waterway and at Rachel Carson along Taylor's Creek.

The deposition procedure typically involves the use of a cutter head dredge and long pipes, known as dredge lines, through which the dredged sediments and water are pumped into a diked basin on the site. Initially, the brackish slurry of sand and mud forms a turbid "lake." As evaporation and drainage cause the sediments to settle out and be exposed, a mound of spoil is left. Regulations prohibit placing spoil on wetlands, therefore dredge material is only deposited on existing spoil mounds.

The newly created upland surface can then be colonized by plants and animals. Initial species invading the sediments are pennywort, *Hydrocotyle bonariensis*, reed, *Phragmites communis,* diodia, *Diodia teres,* broomsedge, *Andropogon scoparius,* panic grass, *Panicum* spp., beach pea, S*trophostyles helvola,* and morning glory, *Ipomoea* spp.

Ground nesting bird species typically found in dune areas also use the open ground. Mourning doves, *Zenaida macroura,* night hawks, *Chordeiles minor,* black skimmer, *Rhynchops niger,* and terns, *Sterna* spp., are among the species occasionally found there.

American beach grass

Beach morning-glory

Sandwich tern

Least tern

Eastern red cedar

Fire wheel

Loblolly pine

Groundsel tree

In time, other herbs and small shrubs gradually invade the spoil areas. Large forbs such as goldenrods, *Solidage* spp., asters, *Aster* spp., blackberry, *Rubus* spp., pokeberry, *Phytolacca americana*, asparagus, *Asparagus officinalis*, mustard, *Brassica* sp., and ground cherry, *Physalis viscosa* spp. maritime, grow sporadically on the edges of the spoil areas and where soil and water is sufficient. Red cedar, *Juniperus virginiana*, silverling, *Baccharis halimifolia,* wax myrtle, *Myrica cerifera*, Spanish bayonet, *yucca* spp., yaupon, *Ilex vomitoria*, and willow, *Salix* spp., then invade, eventually creating a shrub thicket habitat with animal species essentially the same as those discussed under the shrub thicket section. Some areas even acquire forest-like stature with loblolly pine, *Pinus taeda*, live oak, *Quercus virginiana*, and other trees becoming established. However, not all spoil areas succeed to shrub thicket or forest. Portions of interior areas and dikes remain covered with pennywort or reed, even after more than 10 years.

Hard Surfaces

The geology of North Carolina beaches and estuaries primarily involves sediments, such as sand or silt, in

Hard Surfaces

contrast to rocky shorelines found in other regions, like New England. There are a few outcroppings of marine limestone on ocean beaches and in the near shore waters of New Hanover and Carteret counties, but these are exceptions. However, numerous man-made hard surfaces, or substrates, exist along the coast in the forms of rock jetties and wood or cement pilings of docks, bridges, and seawalls.

These types of structures are found within the Reserve at Zeke's Island, Masonboro Island and Rachel Carson sites. Zeke's Island includes a portion of a rock jetty (locally known as "the Rocks") that extends several miles from Fort Fisher to Smith Island. The northern tip of Masonboro Island serves as the anchor point for one of the large twin jetties that stabilizes Masonboro Inlet. The remains of a small rock breakwater are found along the Taylor's Creek side of Town Marsh within the Rachel Carson site.

All of these hard surfaces are places where organisms often not found in the ocean or estuarine communities previously mentioned can become attached and grow. Attaching, or sessile, plants and animals living in this environment must be able to tolerate the water velocities and abrasion of sand-bearing waves, periods without covering water, flooding and temperature extremes. The reserve's rock jetties have impervious surfaces, which are subject to direct

Sea anemone

Eastern oyster

Keyhole limpet

Rock barnacle

Chenille-weed seaweed

Sea hair

Sea Whip

Sargassum

environmental contact with the sun, wind and water, in contrast to the soft sediments available for burrowing organisms.

Organisms organize in vertical zones, depending on their adaptations to fluctuations in water level. This subtidal, intertidal and supratidal zonation creates a more pronounced difference in living conditions during a given tidal cycle than the gently sloping intertidal and subtidal flats.

Jetty organisms living in the subtidal area exhibit further zonation. Brown algae, sea anemones, *Aiptasia* spp., red beard sponge, *Microciona* sp., sea squirts, *Styela* spp., and bryozoans, *Amathia* spp., grow just below the tide line and are exposed only during unusually low tides. Deeper surfaces of the rocks are covered with such organisms as white sea urchins, *Lytechinus variegates*, and red algae. These subtidal animals either graze the algae-coated substrate or strain plankton from the water.

Intertidal species are subject to the greatest changes in daily environmental conditions. Green algae such as sea hair, *Enteromorpha* spp., sea lettuce, *Ulva* spp., and dead man's fingers, *Codium* spp., form patches in suitable habitats mixed with filamentous layers of blue-green algae, *Calothrix* spp. and *Lyngbya* spp. Sessile intertidal animals include the scorched mussel, *Brachidontes exustus*, oyster, *Crassostrea virginica*, and rock barnacle, *Balanus* spp.

The keyhole limpet, *Diodora cayenensis*, and the Atlantic chiton, *Cheotopleura apiculata,* are mobile species in this zone which can hold very tightly to the substrate and graze on algae. The Atlantic starfish, *Asterias forbesi*, uses its tube feet to move and prey upon the shells of oysters, scallops, mussels and clams. Another molluscan predator is the banded tulip shell, *Fasciolaria hunteria*, a large snail with a radula (a tooth-like structure) for boring into the victim's shell.

Waves striking the intertidal zone of the Masonboro island and Zeke's island jetties send spray into the supratidal area. This "splash zone" is often delineated by the high tide barnacle, *Chthamalus fragilis,* a fragile, flattened barnacle which survives by filtering phytoplankton from the spray water. The nonporous plates of its shell prevent it from drying out during low tides. The debris and detritus-feeding sea cockroach is actually an isopod, *Lygida* sp., which crawls over the rocks and hides in crevices for protection. It occasionally gets wet, but will drown if it is under water for a long period of time.

Banded tulip

Baby's ear

Brittle starfish

Red-beard sponge