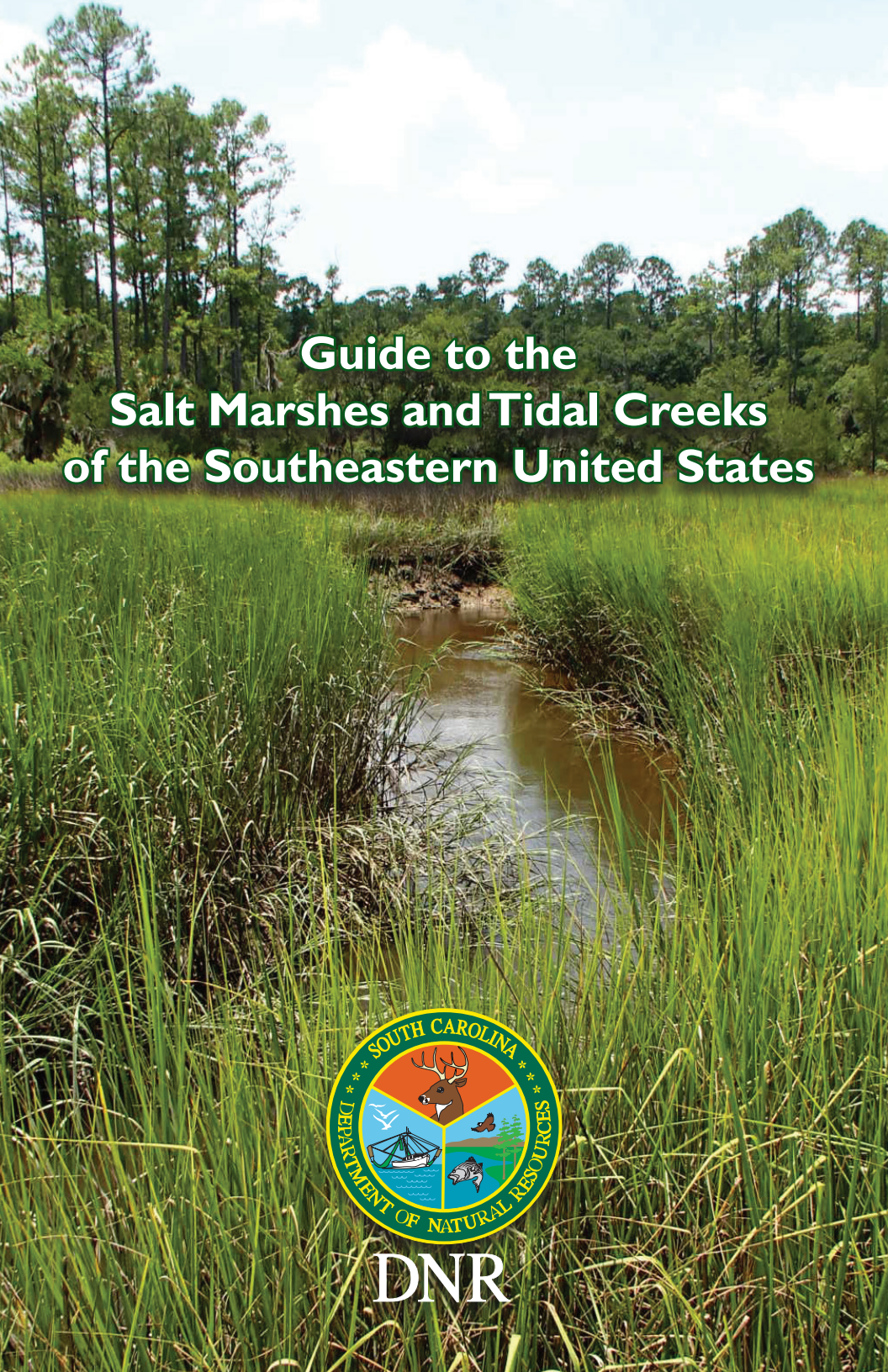

Guide to the Salt Marshes and Tidal Creeks of the Southeastern United States

SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES

DNR

Guide to the Salt Marshes and Tidal Creeks of the Southeastern United States

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EPA United States Environmental Protection Agency

Sea Grant S.C. Sea Grant Consortium

SERTC Southeastern Regional Taxonomic Center

ACE Basin National Estuarine Research Reserve

Carolina CLEAR A Service of Clemson Extension

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How to Use the Guide

If you live along the Southeast coast of the United States, then you are familiar with the expanse of salt marshes and the tidal creeks that dissect them. If you have never seen the beautiful salt marsh-tidal creek ecosystems of the Southeast, then we hope this guide will provide you with a perspective of them and that you will consider visiting one. They provide us with a wealth of unrecognized benefits. Whether you are an angler, a bird watcher, an outdoor enthusiast, or a lover of seafood, the salt marsh-tidal creek ecosystem contributes to the quality of your life.

The *Guide to the Salt Marshes and Tidal Creeks of the Southeastern United States* was developed to provide readers with an appreciation for this ecosystem and how important it is to sustaining our coast and quality of life. We hope you find this guide useful in your explorations, and that it provides you with an appreciation for the value of this important ecosystem. The guide consists of two main sections. The first section describes the physical, chemical, and biological environment as well as the complex interactions that occur between the abiotic (water depth, salinity, temperature) and biotic (animal and plant) realms. This first section also identifies the many "free" benefits this ecosystem provides humans and discusses the historical and cultural role these systems have played in our lives. At the end of the first section, there is a summary of the major threats to the salt marsh-tidal creek ecosystem and a list of actions you can take to conserve it. The second section lists the dominant flora (plants) and fauna (animals) that live in salt marsh-tidal creek ecosystems. This section serves as a handy guide to help you identify and learn about the numerous organisms that call the tidal creeks and salt marshes their home.

Throughout the Guide ***italic/bold*** words highlight the focus of the paragraph, while **bold** words are defined in the glossary. References and Additional Resources are included at the end of the Guide.

Things to consider when visiting the salt marsh-tidal creek ecosystem...

The salt marsh-tidal creek ecosystem is a place of wonder; however, exploring them has risks. Take caution any time you enter a salt marsh or tidal creek and always have a partner with you. They are dynamic systems and the substrate, or surface materials, can change very quickly. We do not want to discourage exploration, just to encourage safe practices. We offer the following suggestions to increase your safety.

- Tidal creeks and salt marshes are composed of "pluff mud." When you step on this mud you risk sinking up to your waist and getting stuck. If you get stuck the best way to escape is to lie on the mud surface and crawl your way to safety.

- Oyster shells are sharp, and falling on them could cause severe cuts that need medical attention. Care should be taken when walking around oyster reefs as well as when walking or digging in pluff mud, as shells may be buried.

- We recommend you wear shoes that lace up tightly and are completely closed, such as tennis shoes. We also suggest long pants and gloves.

- Black needlerush or *Juncus* grows on the high marsh and has sharp, pointed tips. These tips will prick your skin, even through clothes, or injure your eyes. Be careful when exploring areas with *Juncus* growth.

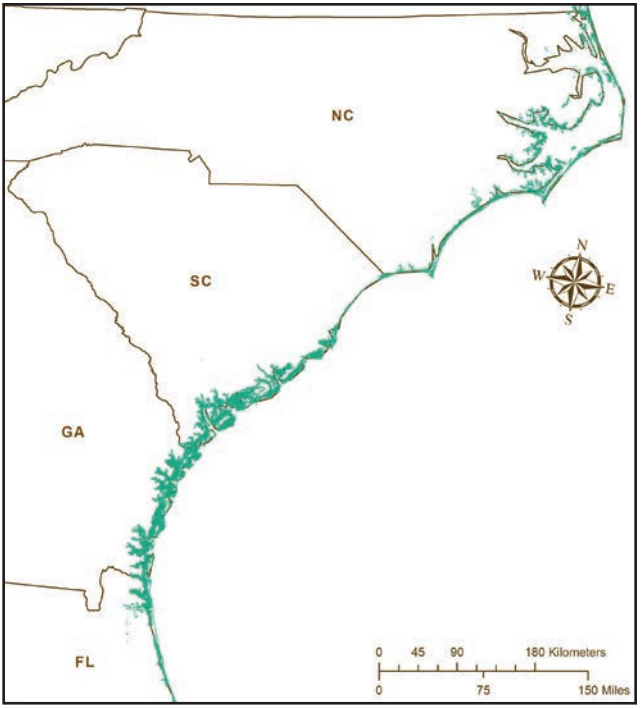
- Regardless of how you are exploring the salt marsh, it is important to know your local tides. You want to know what time high and low tide occur to prevent being stranded or battling the tide to return to your starting point.

- Venomous snakes and alligators can be found in the salt marsh. Care should be taken to observe your surroundings.

What is a salt marsh?

The salt marsh-tidal creek **ecosystem** is a highly productive coastal **wetland** that occurs between upland areas, such as forests and urban environments, and estuaries, where fresh and salt water mix. As an **intertidal** habitat, the surface of the salt marsh is under water at high tide and dry at low tide. A dendritic, or finger-like, network of tidal creeks winds through the marsh and facilitates the movement of tidal water onto the marsh surface and back into the **estuary**.

Along the Atlantic coast of the United States, the salt marsh-tidal creek ecosystem occurs from Maine to Florida. It is, however, most abundant in the Southeast (North Carolina, South Carolina, Georgia, Florida). South Carolina and Georgia each have approximately 350,000 acres of salt marshes and tidal creeks; North Carolina has about 225,000 acres. These three states combined support nearly two-thirds of salt marsh habitat found along the east coast. The northeast Florida Atlantic coast also has approximately 83,000 acres of salt marsh and tidal creek habitats.



Map of Southeastern salt marsh abundance

Kiawah Island, South Carolina

In the Southeast, salt marsh-tidal creek ecosystems are generally found in estuaries along the flanks and behind **barrier islands** such as Kiawah Island, SC, and Tybee Island, GA, as well as along the flanks of larger estuarine systems like the Savannah River, the Charleston Harbor, or the Cape Fear River. They are dynamic systems with varying levels of salinity, or salt in the water. Freshwater is 0 parts per thousand (ppt) and the Atlantic Ocean is 36 ppt. As you travel up the river, salt marshes and tidal creeks have a low salinity, less than 5-10 ppt. Closer to the ocean, salt marshes and tidal creeks are saltier with salinities ranging between 20-35 ppt. Between these two extremes, the salinity of the salt marsh-tidal creek ecosystem varies greatly depending on tidal stage, amount of rainfall, and size of river system. This guide focuses on salt marsh-tidal creek systems which have salinities between 10-35 ppt, and are dominated by a plant called smooth cordgrass, scientifically known as *Spartina alterniflora*.

Today's salt marsh-tidal creek systems began to form about 12,000 years ago, at the end of the Pleistocene epoch when the glaciers that covered much of the earth started to melt and sea level began to rise. As sea level increased and salt water moved inland, bays and lagoons formed behind barrier islands along the Southeast coast. Freshwater input from major river systems deposited sand and fine sediments in the shallow regions creating sand bars and mud flats. The elevation of the sand bars and mud flats rose above low tide, giving salt tolerant plants (**halophytes**), particularly *Spartina alterniflora* the opportunity to grow. The roots and stems of *Spartina* trapped incoming sediment and stabilized it, thus creating a marsh platform. As vast expanses of salt marsh grew, runoff from adjacent uplands in combination with the rising and falling tides resulted in the creation of numerous tidal creeks which transect the marshes.

The **abiotic** or physical properties of the salt marsh-tidal creek ecosystem are extremely variable and strongly influence the system's **biotic** properties, which include the productivity, diversity, and abundance of plants and animals that occur there. The flora and fauna of this ecosystem are adapted to changes in environmental conditions that occur hourly, daily, seasonally, annually and on even longer time scales. The major physical variables influencing the salt marsh-tidal creek ecosystem include the tides, salinity, sediments, air and water temperature, precipitation, and sunlight.

The Southeastern salt marsh-tidal creek ecosystem has **semi-diurnal** tides, meaning they experience two high tides and two low tides each day, each lasting about six hours. The tidal range, or difference between low and high tide, ranges from about ten feet (3m) in Georgia to about three feet (1m) in North Carolina and Florida. Tides result from the moon and sun's gravitational pull on the earth's oceans. Approximately twice a month, around the new moon and full moon, tides reach their maximum height (spring tides). When the moon is at the first quarter or third quarter, the tide's range is at its minimum height (neap tides). The concave shape of the Southeast coast in combination with the broad and shallow continental shelf from Cape Hatteras, NC to West Palm Beach, FL, termed the **South Atlantic Bight**, funnels large volumes of water into this area causing the largest tides to occur in the middle of the Georgia coast. Maximum tidal length decreases to the North and South of this point.

Tides continually move salt water into and out of salt marsh-tidal creek systems. On flooding tides, the marshes and creeks are flooded with higher salinity water as well as fine sediments and **nutrients**. During periods of heavy rainfall and ebbing tides, the creek and marsh can be inundated with freshwater, decreasing salinity. Salinity of the water is a major factor determining which plant and animal species will successfully inhabit the salt marsh-tidal creek ecosystem. Organisms living in the salt marsh-tidal creek ecosystem must be adapted to survive in variable salinities.

Low tide

Mid tide

High tide

Researchers in pluff mud

As the water moves into the marsh on the flooding tide, the suspended particles of fine sediment settle out on the marsh surface and edges of tidal creeks. The stems of *Spartina* are especially effective at reducing tidal currents and facilitating fine sediment deposition. The greatest amount of fine sediment accumulates where *Spartina* stems are the most dense. The sediment in salt marsh-tidal creek systems can range from coarse sand to very fine mud. Traversing a sandy area in a marsh is quite easy; however, walking in muddy sediments called **pluff mud** can be difficult and frustrating.

The Southeast coast has a subtropical climate. Average monthly winter air temperatures range between 38-59° F (3-15°C). Average monthly summer air temperatures range between 70-90°F (21-32°C). Rainfall varies along the Southeast coast; however, it averages around 50 inches (1,270mm) per year.

Temperature and sunlight greatly influence the color and condition of salt marsh plants, particularly *Spartina alterniflora*. *Spartina alterniflora* is an annual plant reflecting the seasons in its growth and color. In spring, *Spartina* begins to grow and the marsh takes on a brownish green color caused by the combination of new growth and dead stems remaining from the previous year. In the summer, *Spartina* reaches its maximum height and takes on a distinct bright green color. By fall, small white flowers develop along the upper stalks, forming seed heads full of hundreds of seeds no bigger than a grain of rice. The leaves then turn a golden brown color and the seeds are dispersed. In winter, *Spartina* stems turn brown and die. The stems break off

at the base and accumulate on the marsh surface as mats called "**wrack.**" Winds and tides, **decomposition** by bacteria and fungi, and grazing of marsh animals, such as the marsh periwinkle snail, break the wrack into smaller and smaller pieces, called **detritus**.

Spring

Summer

Fall

Winter

Spartina reproduces in three ways including: (1) seed formation and dispersal by wind and tides, (2) fragments of living plants that break off and form new ones, and (3) roots, called rhizomes, which spread underground and sprout new plants.

The salt marsh-tidal creek ecosystem may appear to be a homogenous environment, or **monoculture**, dominated by *Spartina*, but within the marsh system a variety of zones and habitats occur including the upland border, marsh platform, marsh hammocks, high marsh, low marsh, tidal creeks, mud flats, sand flats, and oyster reefs. Between the estuary and the uplands, gradual changes occur in the type and abundance of the marsh plants and animals. Elevation (height above mean sea level), tidal height, and salinity are the dominant environmental factors controlling the zonation or distribution of habitats. Elevation change as small as a couple of inches is all that is needed to produce changes in the types of plants and animals that occur. When you visit the salt marsh, you can see these changes as you walk from the drier and higher upland down towards the creek.

When you first approach the salt marsh by land you will find yourself in the marsh ***upland border***. This is the zone between the high marsh and the uplands. The elevation in this transition zone is above the highest tides. Plants occurring here are tolerant of salt spray and occasional storm surges. They are also adapted to living in coarse sandy soils that do not retain freshwater. Plants living in the marsh upland border generally have thick, waxy leaves able to store freshwater during periods of low rainfall. Sea ox-eye daisy and marsh elder are characteristic plants of the upland border.

Upland border

As you look out at the marsh from the upland border, you will see the ***marsh platform***. The marsh platform is the primary surface of the salt marsh and refers to the flat, broad area

Marsh platform and tidal creek in Florida

extending landward from the water. The platform accumulates sediment brought in with the tide and provides a stable surface for vegetation growth. Tidal creeks and rivulets (very small tidal creek like structures) dissect the platform creating the low marsh and the high marsh.

The marsh platform supports glasswort and black needlerush in higher elevations to *Spartina* in lower elevations. Many terrestrial organisms, such as raccoons and great blue herons, and aquatic organisms, such as blue crabs, red drum, and spot, feed throughout the marsh platform.

Marsh hammocks are essentially islands in the middle of the salt marsh. Marsh hammocks vary greatly in size from less than an acre to several hundred acres. Most are small (less than a few acres) and undeveloped; however, some larger ones are developed for residential homes. The secluded nature of undeveloped marsh hammocks provides an important **refuge** for wildlife from nearby development. They play a particularly important role as resting, nesting, and feeding

Small marsh hammock

areas for small migrating birds. The colorful painted bunting, for example, nests on most hammock islands. Marsh hammocks are also one of the last remaining habitats for some amphibians and reptiles, including the diamondback terrapin. Deer, bobcat and raccoon use hammocks as refuges during high tide, while wading birds and alligators (in fresher areas) find hammocks suitable for nesting grounds. Plant life on a marsh hammock can also be very diverse. A half-acre hammock may support only a few small live oaks, while larger hammocks support maritime forest communities with live oak, wax myrtle, saw palmetto, yaupon holly and many other plant species.

Within the marsh platform, the ***high marsh*** zone is covered with salt water for only about one to two hours each day, with the upper extent of the high marsh flooding only a few times a month during spring tides. The transition from the relatively muddy low marsh to the sandier high marsh requires only a few inches change in elevation. *Spartina* begins to experience competition for resources from plants, such as black needlerush, saltgrass, and glasswort in the high marsh, and may only reach heights of three to twelve inches (eight to thirty cm). While any plant found in the high marsh needs to be salt-tolerant, freshwater running off from the mainland is also essential for their growth and success.

Salt panne with common glasswort

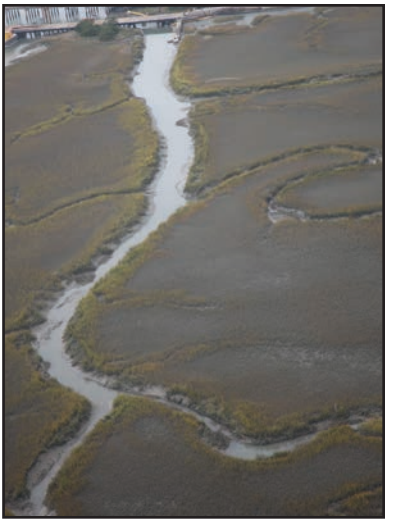
The thin layer of water over the high marsh evaporates quickly resulting in high levels of salt in the sediment. In certain areas of the high marsh, called ***salt pannes***, sediment salinities approach 100 ppt during the summer. The succulent plant, common glasswort, is able to store salt in its branch-like leaves and is the dominant vegetation of salt pannes.

Salt excretion on leaf of Spartina

The ***low marsh*** zone spans from the tidal creek bank to the high marsh and is covered with saltwater for half of the day. In the Northeast, salt marshes tend to have narrow bands of low marsh; however, in the Southeast the low marsh can often be found covering miles of habitat, making it a predominant habitat of many salt marsh-tidal creek systems. The low marsh zone provides an abundance of food, including ribbed mussels, fiddler crabs, and small **invertebrates** for larger animals. Only one type of grass, *Spartina alterniflora*, has the **adaptations** needed to withstand the amount of tidal flooding and salt content experienced by the low marsh. These adaptations include: (1) glands along the grass blades that excrete salt, making it possible for *Spartina* to consistently be exposed to saltwater; and (2) an extensive root-rhizome system that acts as an anchor, stabilizing it during the tides and holding it steady against storms and high wave energy. *Spartina* growth and production in the low marsh varies. Immediately adjacent to the creek bank, where the greatest amount of pore water flow and nutrients exist, *Spartina* can reach heights between five to eight feet (1.5-2.4m). In the interior region of the low marsh, where less nutrients are deposited and salinity is higher, *Spartina* height ranges from two to four feet (0.6-1.2m).

Tidal creeks are branching structures that meander through and shape salt marshes. They are the major water link between salt marshes and the open estuaries. Tidal creeks are also a conduit

for **stormwater runoff** from the upland to the open estuaries. These creeks, some almost dry at low tide, are particularly important as nursery areas for many species of fish and invertebrates. Wave after wave of recreationally and commercially valued species, including spotted seatrout, red drum, spadefish, spot, black drum, blue crab, white shrimp, and brown shrimp, enter tidal creeks as juveniles to continue their life cycle before moving to deeper water. Even some fish we normally associate with the open ocean, such as grouper and barracuda develop in tidal creeks during their earliest years. The quiet, protected creeks provide an abundant food supply and give juveniles respite from predation as well as access to the marsh platform at high tide. Large fish predators, such as flounder, will lurk at the mouths of tidal creeks feeding on the smaller organisms that are flushed out on ebbing tides. Wading birds and other avian predators also feed on organisms in the shallow creeks at low tide and on the marsh platform at high tide.



Winding tidal creek

The low marsh and tidal creek zones are the predominant areas pluff mud occurs, particularly along the edges of creeks. Pluff mud gives off the characteristic "rotten egg" sulfuric smell many quickly associate with salt marsh-tidal creek systems. While the odor seems foul to some it is actually a healthy indicator of a process called **anaerobic respiration**. Anaerobic respiration uses sulfates from the water and releases hydrogen sulfide into the mud, creating that sulfuric odor. Mud flats lack oxygen, however certain bacteria and fungi in the mud thrive in low oxygen

Fiddler crab near its burrow

environments. This **anoxic** habitat may not seem well suited for animal life at first glance. However, burrowed into the mud are numerous organisms such as clams, fiddler crabs, and small worms which have adapted to live in low oxygen environments. These organisms in turn attract larger predators that feed on them.

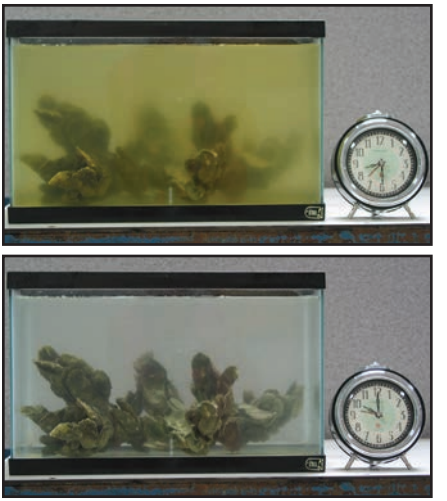
Mud flat

Mud flats are intertidal, non-vegetated, soft sediment habitats occurring in the areas of tidal creeks with weaker currents. Fine sediment particles tend to accumulate in these areas and form muddy intertidal habitat. ***Sand flats*** are intertidal, non-vegetated environments that occur in areas with stronger currents. Sand particles tend to accumulate in these areas and form sand bars. Mud and sand flats are both depositional features, meaning tidal currents continually modify their size and shape. Sand and mud flats are inhabited by abundant populations of burrowing clams, crustaceans and worms, and are important feeding grounds for shore and wading birds, fish, crabs, and rays.

One of the most recognized habitats in the salt marsh-tidal creek ecosystem is the ***oyster reef***. Spawning peaks from April to October and is dependent upon temperature and food availability. Early life stages are free floating in the water as plankton, but the final larval stage must attach to a hard surface and transform into a small oyster, called spat, before it can continue to mature. Most often, the shells of other oysters, dead or alive, turn out to be the best solid surface for attachment.

Spat growing on oyster shell

As oysters continually grow and build upon each other, expansive reefs are formed in tidal creeks. Oysters are filter feeders, and adult oysters are capable of filtering up to four gallons of water an hour. This makes oysters extremely important in improving water quality by filtering out particles from the water, including bacteria, algae, detritus and suspended sediments. One of the best indicators of impaired water quality is when oyster reefs are restricted from being harvested because levels of fecal bacterial indicators are too high. Oyster reefs are also vital in protecting shorelines from **erosion** and provide habitat for crustaceans, worms, and fish. The reef is a particularly important refuge for juvenile fish as it provides a bountiful food supply as well as shelter from predators. For all of the above reasons, oysters are often referred to as a **keystone species**, or a species that shapes an ecosystem and on which a number of other species in the ecosystem rely.



Timed oyster filtering

Section of an oyster reef

As discussed, the twice-daily ebb and flow of the tides greatly influences life in the salt marsh-tidal creek ecosystem. The rapid and regular transition from wet to dry, salty to fresh, and cold to hot depending upon season, greatly limits the types of plants and animals that can survive in this ecosystem. However, the rich soil and abundant sunlight make this ecosystem very productive, allowing the animals and plants adapted to these changing conditions to develop abundant populations which contributes to the complex and intricate food web of this ecosystem.

Animal tracks through the salt marsh

The salt marsh-tidal creek ecosystem serves as primary habitat for a rich variety of animal life. Some animals live in the ecosystem permanently, while others are transient. From the worms living in the mud to the birds flying over it, a number of organisms use the marsh. Raccoons can be seen scouring the mud for a meal of mussels and fiddler crabs, while a diamondback terrapin lays eggs on a nearby hammock. Small invertebrates, like the mud snail and periwinkle snail, graze directly on sediments and *Spartina* stems for algae and microorganisms. When the tide comes in, blue crabs feed on the periwinkle snails that climb up the stalks of *Spartina*, and wading birds and red drum in turn prey upon the blue crabs. Large fish predators hunt in deeper sections of tidal creeks preying on shrimp, crabs, and small fish that may wash into the nearby estuary on the ebbing tide.

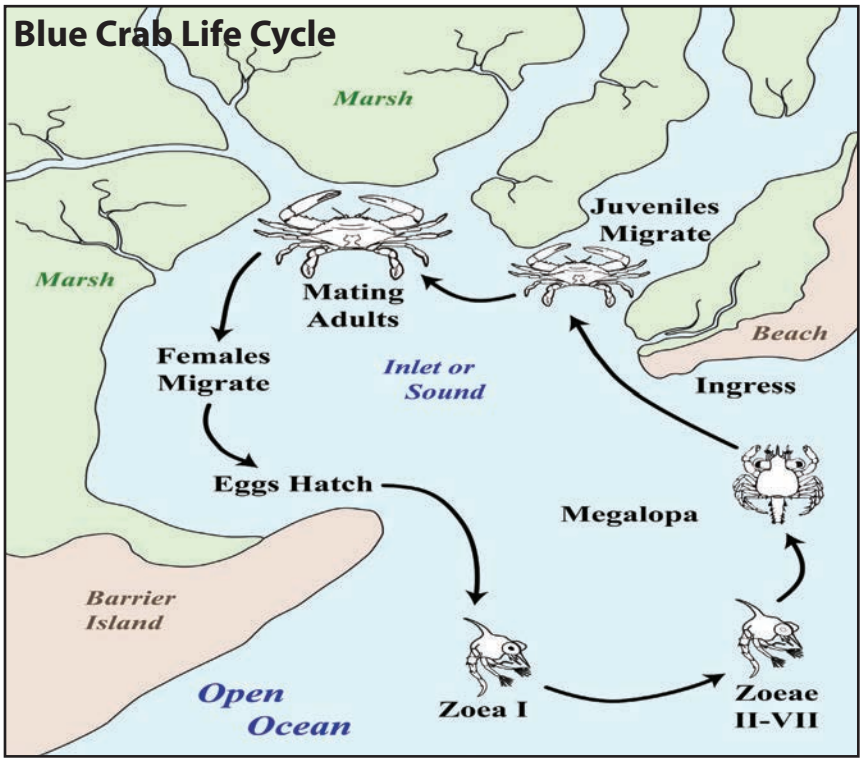
Spartina leaves and stems and the algae growing on the marsh surface form the base of the salt marsh-tidal creek food web. Most of the nutrient production of the salt marsh-tidal creek ecosystem is consumed as part of what is referred to as a detritus-based food web. In the fall and early winter, tidal currents, waves, wind and storms dislodge and break up decaying leaves and stems of *Spartina*, and deposit this material throughout the salt

marsh-tidal creek ecosystem as wrack. Microscopic organisms such as bacteria, fungi and small algae attach to this dead plant matter and break it into smaller and smaller particles. The detritus, including the microorganisms attached to it, are consumed by a wide variety of organisms including mussels, snails, worms, oysters, and crustaceans, as well as juvenile and adult fish.

Spartina wrack

The salt marsh-tidal creek ecosystem is crucial as a nursery ground. Some estuarine animals, such as mud minnows and snails, complete their life cycle within this ecosystem. Others, such as white and brown shrimp, red drum, mullet, and blue crab as well as many other recreationally and commercially valuable fish species spawn in the open estuary and ocean where initial developmental occurs. After a few weeks, the early life stages of these ocean and estuary spawning organisms are transported up tidal creeks via tides and into the marsh where food is abundant and they are relatively safe from predators. These juveniles are adapted to, or can tolerate, the naturally low dissolved oxygen levels found in these systems for long periods of time whereas the larger animals cannot. As they grow, the juvenile animals continually move between the flooded marsh platform at high tide and tidal creeks at low tide, in search of food and protection from predators too large to swim into the shallow water. This process allows rapidly growing juveniles to mature in relative safety. Some species will stay in the marsh and continue to live and reproduce, while others will move out into the open water of the estuary to complete their life cycle.

Many species of birds feed on the small fishes and invertebrates that live in the salt marsh. Terns and osprey dive for fish visible in the shallow water, while sandpipers and their relatives probe exposed flats for small snails and marine worms. Only two


Blue Crab Life Cycle
Marsh
Marsh
Juveniles
Migrate
Mating
Adults
Females
Migrate
Inlet or
Sound
Beach
Ingress
Eggs Hatch
Megalopa
Barrier
Island
Open
Ocean
Zoea I
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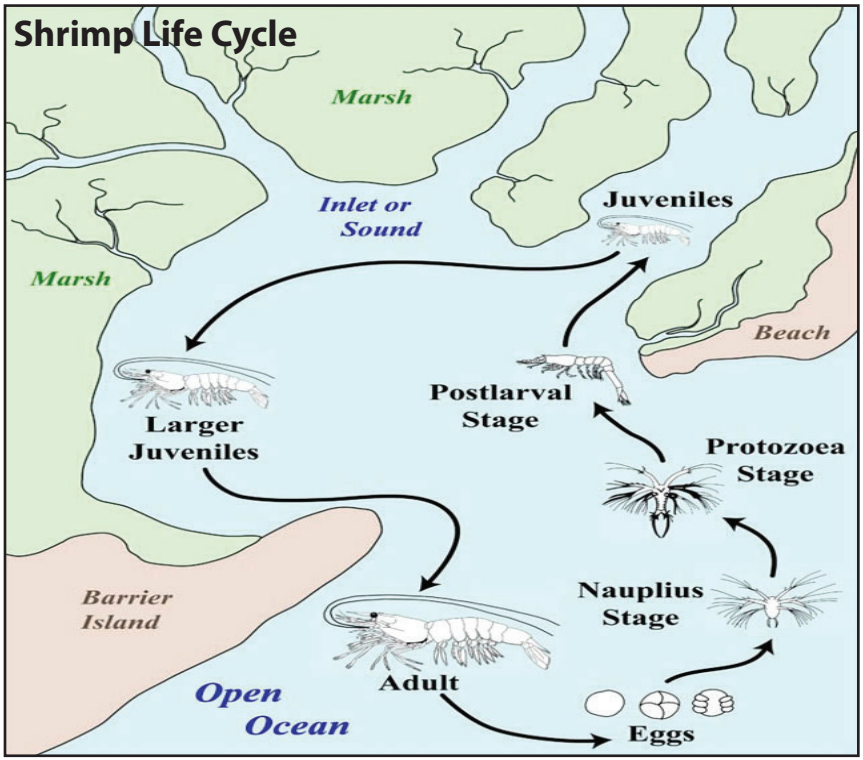
II-VII


Shrimp Life Cycle
Marsh
Inlet or
Sound
Juveniles
Marsh
Beach
Postlarval
Stage
Larger
Juveniles
Protozoea
Stage
Barrier
Island
Nauplius
Stage
Adult
Open
Ocean
Eggs

birds, the clapper rail and marsh wren, nest in Southeastern salt marshes. Clapper rails, often heard but seldom seen, hunt for fiddler crabs among the stalks of *Spartina* and black needlerush, where they build their nests above the reach of the tides. Marsh wren, prolific singers during the spring breeding season, weave tall *Spartina* stems into messy nests along the creek banks.

One of the few permanent reptiles of the salt marsh-tidal creek ecosystem is the diamondback terrapin which moves into the grass during high tide to feed on periwinkle snails and will move to high ground to lay its eggs above the high tide mark. This small turtle comes in a variety of colors, from spotted and light green to dark brown and black. Alligators often pass through **brackish** marshes but usually avoid high salinities.

A few mammals enter the marsh platform to forage while the mink, an excellent swimmer, searches the marsh and small creeks for fish, shrimp, and other aquatic prey. Bottlenose dolphins will leave the deeper water of the estuary to find prey in shallow creeks. If you are lucky, you may see dolphins feeding along creek banks, a practice called strand feeding or mudding!

As a result of these biological interactions, the salt marsh-tidal creek ecosystem is one of the most productive and complex ecosystems on the planet. In fact, the amount of biomass the salt marsh-tidal creek ecosystem produces, recycles, and transports is rivaled only by the rainforest!

Birds probing for prey in the marsh

Ecosystem Services

Salt marshes and tidal creeks provide us with a wealth of benefits, referred to as ecosystem services, including maintaining healthy water, protecting us from flooding and erosion, providing nursery and essential habitat for commercial and recreational fisheries, and supporting recreational activities that have become part of the coastal lifestyle. The system is an attraction for many and offers a unique experience every time you visit it. We need to take actions that reduce risks to the salt marsh-tidal creek ecosystem to make sure people are able to continue enjoying them.

One of the most important benefits the salt marsh-tidal creek ecosystem provides is maintaining healthy ***water quality***. Poor water quality can be a result of excess nutrients, toxins, and/or suspended sediment. A healthy salt marsh has the ability to greatly reduce these pollutants. Excess nutrients and chemicals are filtered out and can be taken up by *Spartina* plants and stored in their roots and rhizomes as well as broken down by bacteria in sediments. The processing functions of the salt marsh-tidal creek ecosystem help to remove pollutants from the larger estuary.

Spartina roots and rhizomes

Sediments in the water are also an important component of the tidal creek-salt marsh system. In general, the estuarine waters of South Carolina, Georgia, and Northeast Florida have higher

sediment levels or **turbidity** than North Carolina and Southeast Florida. The sediment can keep sunlight from penetrating through the water. This is likely why true sea grasses are not found in South Carolina and Georgia but are found in North Carolina and Southeast Florida. Suspended sediments are also important in sustaining the surface elevation of the marsh and in their pollutant processing functions. Pollutants will often adhere to the sediments in water and settle on the marsh surface due to the drag of the plant stems. Some sediment is good to sustain the marsh elevation but too much can limit sunlight penetration and decrease photosynthesis rates.

The tides are also important in controlling the water quality of tidal creeks and salt marshes. In areas with larger tides (South Carolina and Georgia), the constant movement of larger amounts of water in and out twice per day helps to flush the system. In areas with lower tidal ranges and reduced flushing (North Carolina and Florida), **eutrophication** (excess nutrients) may be an issue and result in fish kills due to the poor oxygen levels. That said, tidal creeks do have naturally low and fluctuating oxygen levels. The low oxygen is thought to keep out the larger predators, making creeks and marshes good nursery habitat for smaller organisms that can withstand lower oxygen levels.

Salt marsh buffer between a tidal creek and surrounding development

The Southeast has over 1 million acres (405,000 hectares) of salt marsh-tidal creek habitat, all of which play an important role in ***buffering*** the coast and minimizing damage from storm surge. The salt marsh-tidal creek ecosystem, particularly vegetation along creek banks and oyster reefs, acts as a barrier that helps to reduce wave energy and current velocity. The natural buffering of the salt marsh helps protect upland areas and private property from flooding and erosion during storms.

Another benefit of the salt marsh-tidal creek ecosystem is the ***reduction of carbon dioxide*** (a **greenhouse gas**). Plants take up carbon dioxide from the atmosphere during photosynthesis, converting the carbon into living and dead plant material. Along the coastline, this is termed "**blue carbon**", referring to the carbon captured by coastal plants such as mangroves, sea grasses, and salt marsh grasses and then stored in coastal ecosystems. These coastal plants are reported to **sequester** 100 times more carbon than forest plants. Since there are thousands of acres of salt marsh in the Southeast, this makes them a significant blue carbon sink. Carbon uptake or sequestration occurs throughout the year but can take different forms. Carbon can be sequestered in the mud, in healthy plants, and in the dead grass as it accumulates as wrack in the winter. This ability makes the salt marsh-tidal creek ecosystem an invaluable habitat for sequestering carbon, reducing greenhouse gases, and ultimately reducing impacts on our climate.

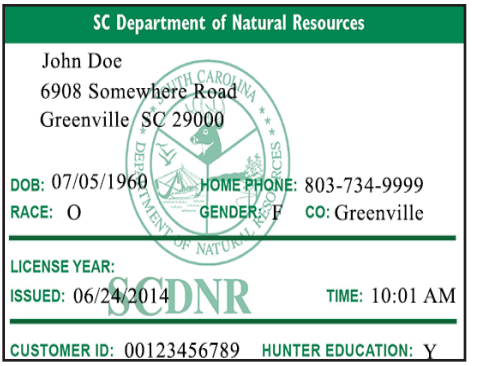
Another one of the primary benefits the salt marsh-tidal creek ecosystem provides citizens is ***seafood***. Seafood consumption is an integral part of Southern culture. Oyster roasts, crab boils, and frogmore stew are frequent staples at parties throughout the Southeast. Along the Southeast coast, our most important fisheries

Blue crab in trap

Shrimp trawl

are shrimp, blue crabs, fish, oysters, and clams. The commercial and recreational fishing industries for these animals contribute millions of dollars to the coastal economy and employ thousands of people.

In 2014, the SCDNR reported the commercial seafood industry provided over $23 million to the South Carolina coastal economy. The shrimp fishery alone brought in over $8 million. The salt marsh-tidal creek ecosystem also supports recreational seafood harvesting. Recreational fishing is one of the more popular ways for people to interact with the salt marsh-tidal creek ecosystem. In 2014, the state of North Carolina reported about 304,000 residents purchased recreational fishing licenses, with another 165,000 purchased by non-residents. The value of recreational fishing on each state's revenue is significant, and a large portion supports efforts for harvesting and conservation. At some point in their life cycle, the salt marsh-tidal creek ecosystem provides essential habitat for over 75% of our important fisheries species.


SC Department of Natural Resources

John Doe
6908 Somewhere Road
Greenville SC 29000

DOB: 07/05/1960 HOME PHONE: 803-734-9999
RACE: O GENDER: F CO: Greenville

LICENSE YEAR:
ISSUED: 06/24/2014 TIME: 10:01 AM

SCDNR

CUSTOMER ID: 00123456789 HUNTER EDUCATION: Y

SC recreational fishing license

Without healthy salt marsh-tidal creek habitat, it is unlikely Southeastern fisheries would be as productive and as important to our economy as they are today. We have a responsibility to protect our state's natural resources, like the salt marsh and tidal creeks, so that they can continue to support both the wildlife and people of the Southeast that rely on them.

Finally, salt marsh-tidal creek habitats provide coastal residents and visitors with many ***recreational opportunities***. Each year, thousands of people spend numerous hours sailing or paddling in our estuaries, admiring the scenic view, and exploring tidal creeks by boat. They spend long afternoons watching dolphins, tracking birds through the sky, hiking along the marsh-upland edge, and hunting water fowl. Artists from all over the world travel to the Southeast coast for the opportunity to paint, draw, and photograph the marsh landscape and wildlife. With its ever-changing nature, the salt marsh is an attraction for many, and offers a unique experience every time one interacts with it.

Children fishing off of a public dock

Resident enjoying a day of birdwatching in the marsh

Historical and Cultural Interaction

Native American Use

Before European exploration of the Southeast, these lands were inhabited by a number of Native American tribes, such as the Seminole in Florida, the Guale in Georgia, the Yemassee in South Carolina, and the Waccamaw in North Carolina. The Native Americans living along the coast needed to adapt and survive to the ever changing salt marsh-tidal creek ecosystem, and learn how to live with and sustain themselves off it. Many local plants were used in everyday life: sharp yucca leaves were used for cordage, needles, and medicine; Spanish moss was used as stuffing; and yaupon holly was used in a number of traditional rituals. For food, Native Americans participated in activities very similar to what we practice now, including creating net-like structures to catch crabs and fish in the tidal creeks, harvesting oysters, clams, and whelks in the marsh mud, and hunting terrestrial animals such as deer which grazed near the marsh platform. Most notably, Native Americans relied heavily on the extensive oyster beds found in the tidal creeks. Not only did the oysters themselves provide a great source of nourishment, but the sharp, bowl-like shape of the shells made them useful in a number of ways as tools.

Evidence of Native Americans' reliance on oysters is found today in the form of shell rings or middens. A **shell midden** is essentially an area where huge numbers of empty oyster shells were piled up by local tribes, some think as trash piles, and are still intact today. In Awendaw, just north of Charleston, SC, there is one midden nearly the size of three football fields! A number of smaller middens can be found, however, by doing some research and simply exploring the maritime forests near the salt marshes. The middens have changed the soil chemistry such that unique and rare plants can be found growing on them, such as Carolina buckthorn, Southern sugar maple, and Godfrey's forestiera.

Gullah/Geechee: De Marsh and We

(Text contributed by Queen Quet)

Southeastern estuaries are known for their picturesque marsh views and for the many creatures that make this marsh their home. However, there are those rare times those making their way to the shorelines will see a **bateau boat** coming from amidst the marsh grasses and see the people that have called this home for over 400 years - the Gullah/Geechee. Gullah/Geechees have lived on the Sea Islands from Jacksonville, NC, to Jacksonville, FL, since the 1600s when their African ancestors were forcibly brought to these islands. These islands and 35 miles inland to the St. John's River encompass the home of the Gullah/Geechee people through which runs the US National Heritage Area called the "Gullah/Geechee Cultural Heritage Corridor".

Gullah/Geechee history, heritage, and culture thrives on the salt waters and marshes from which they have fed their spirits via sacred healing ceremonies including libations and baptisms over the generations. They have also fed their bodies via the continued seafood harvesting practices that are yet alive in the traditional Gullah/Geechee communities on the Southeastern coast. Gullah/Geechees are known for being "boatmen" who craft

Gullah/Geechee men casting a net

the flat bottomed wooden bateau boats they use to navigate the rivers and estuaries as they take out handmade cast nets to catch shrimps and fish. There are also those that go out to dig for clams and pick oysters. Many that now go out into the waters to pull in crab traps actually grew up going out along the shores on foot and catching blue crabs hiding in the marsh by using a traditional Gullah/Geechee line or stick and a bucket.

For many generations the Gullah/Geechees have been an active part of maintaining the shoreline because they know to only take what they need to sustain themselves and their families. They also replanted oyster shells along the shorelines in order to insure there would be future oysters. The community is just coming to realize that this practice also insures there will continue to be *Spartina* marsh grasses which help the coast to remain in place and to better stand against strong tides, sea level rise and storms.

While these grasses are the habitat for the numerous shellfish and fish that Gullah/Geechees consume as a part of their daily diet, they are also part of the sweetgrass basket tradition of the Gullah/Geechee. Bulrush grass is commonly cut and used to enhance the designs of these baskets that have come to be an icon of Gullah/Geechee culture and the continuation of African traditions in the Americas.

Traditional sweetgrass basket

Gullah/Geechees often say, "De wata bring we and de wata gwine tek we bak!" Just going to the marsh takes Gullah/Geechees spiritually back to the homeland of their ancestors where the marsh bends and bateaus continue to journey out between them just as they still do in the Gullah/Geechee lands.

Rice Cultivation and other Agriculture

In the 19th century, tide-influenced rice cultivation flourished in the Southeast. While it was focused in the freshwater marshes, it still played a significant role in the entire marsh ecosystem, and is an important aspect of marsh history in the Southeast. As planters experimented with a number of approaches, they quickly realized that taking advantage of the large and predictable tides would result in the most efficient method of rice cultivation. Thousands of acres of marshland and tidal rivers were altered by networks of **dikes** and canals to create rice fields. Structures, called trunks, were strategically placed along the dikes and used to control the water level in the fields. During the early and mid-1800s, this system of **impoundments** allowed the rice industry to become the dominant form of agriculture along the South Carolina and Georgia coast.

A trunk along the edge of a dike system

With the end of the Civil War and the loss of slave labor, rice production dropped considerably. After 1870, rice production continued at lower rates until the early 1900s when the Southeast suffered from a particularly intense series of hurricanes which damaged many of the dikes and trunks, returning natural tidal flow and ruining the rice fields. This marked the end of the rice industry in the Southeast. However, remnants of the old fields still exist. For example, approximately 15% of South Carolina's tidal freshwater marshes are still impounded and primarily used as migratory stopover for waterfowl.

Threats to and Protection of the Salt Marsh

Southeastern coastlines are alluring places for millions of residents and visitors. In fact, over 50% of the U.S. population lives in coastal zones throughout the country. The scenic views and natural beauty of the salt marsh-tidal creek ecosystem are major factors attracting people to our coasts. As the country's population continues to grow, it becomes increasingly important to take actions to protect the salt marsh-tidal creek ecosystem for enjoyment and use by current and future generations.

Coastal development in the Southeast is occurring in a manner that is consuming forests at a rate many times faster than the human population is growing. This pattern of development, called urban sprawl, creates communities with large amounts of paved areas, such as roads, parking lots and roofs. These **impervious surfaces** prevent rainfall from filtering slowly into soils, and instead flush it quickly into marshes and tidal creeks. This stormwater runoff, called **non-point source pollution**, contains nutrients, chemicals like gasoline and oil, pathogens like fecal bacteria, and sediments. This pollution has the potential to cause harm to our salt marshes and tidal creeks. Watersheds with greater than 10% impervious surface levels have increased chemicals, nutrients, and fecal bacteria in tidal creeks. Tidal creek biotic health is impaired when the amount of impervious surface within a watershed exceeds 20-30%. We can minimize these impacts by taking simple steps to reduce the amount of impervious surface and pollution. Communities are starting to encourage **low impact development best management**

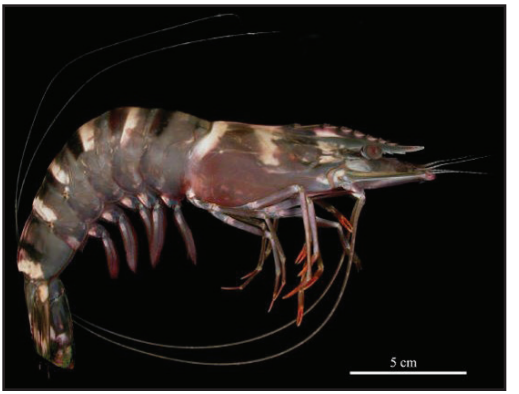
Development along a marsh

practices like pervious concrete and upland **vegetative buffers** that filter larger amounts of runoff through soils and vegetation to sequester pollutants. Public education programs have been initiated to help reduce the chemicals, nutrients and pathogens entering our salt marsh and tidal creek systems.

Commercial and recreational fisheries provide significant economic benefits to the Southeast region and to our quality of life. Most of the harvested species depend on the salt marsh-tidal creek ecosystem as a nursery and refuge from predators. ***Increased fishing pressures*** have the potential to reduce the population of commercially and recreationally important species faster than they can reproduce. The capture of **non-target organisms**, called by-catch, during recreational and commercial fishing activities can have indirect impacts as well. For example, the diamondback terrapin often enters crab traps, and if kept underwater for too long, these turtles will drown. Resource management agencies carefully monitor harvests, by-catch, and populations levels, and use this information to establish fishing limits and regulations. Fishing restrictions, practicing catch and release, and new by-catch reducing technologies, such as terrapin excluder devices, enable us to conserve our marine resources.

Diamondback terrapin in a crab trap

Invasive species are plants or animals that are not naturally found in a location and which aggressively spread when introduced into new habitats. Accidental and intentional introductions of invasive species are frequently a threat to **native** organisms. They compete with native species for resources and may expose them to new pathogens and disease, often resulting in the invasive species taking over an ecological role, or **niche**, of a native organism. Non-native species are being introduced all the time through ocean currents, **ballast water**, and as hitchhikers on boats and animals. Fortunately, few organisms have the adaptations that allow them to sustain their populations in the salt marsh-tidal creek ecosystem, and very few invasive species are found there. Several invasive species that do occur include the tiger shrimp, the macroalgae *Gracilaria*, and the reed *Phragmites*. As new invasive species are introduced, precise tracking of their status and distribution is imperative; however, it can be very difficult to achieve.



Penaeus monodon

Tiger shrimp, *Penaeus monodon*, are a large shrimp (up to 12 inches, 30cm; 1 pound, 453g) with black stripes. Tiger shrimp are native to the Indo-Pacific, Asian, and Australian waters.While the exact method of their introduction is unknown, it is thought that they entered Southeastern waters by ballast water, movement by current transport and/or releases from an aquaculture facility. Adult tiger shrimp tend to be much larger than their native counterparts and may prey on them. They are also thought to compete with native shrimp for food and habitat resources. Sightings of tiger shrimp in the Southeast are increasing. Biologists are continuing to track the tiger shrimp's introduction by asking recreational and commercial shrimpers to report the location and frequency of any tiger shrimp caught in their nets.

Gracilaria vermiculophylla

Gracilaria vermiculophylla is a branched red macroalgae, approximately eight inches (20cm) long and was originally native to Asia. In Asia, it is cultured for use in food products such as ice cream and jelly. The invasion of *Gracilaria* into the Southeast has occurred relatively recently and may have resulted from ballast water, hull fouling, or Pacific oyster imports. *Gracilaria* has invaded mud flats that have historically not had significant amounts of algae. It has changed the mud flat habitat by providing vertical structure where none was before, altering species compositions and oyster growth. Depending on the animal, it can have positive and negative effects. How this species will alter the salt marsh and tidal creek ecosystem in the future is unknown. Trawl nets have been known to become clogged with *Gracilaria*, impacting shrimp fisheries. You will most likely see *Gracilaria* washed up on land, covering a mud flat, or caught in your nets.

Phragmites australis

Phragmites australis is a tall reed which can reach heights of ten to twelve feet (3-3.5m) and can occur in less saline areas. Three separate sub-species of *Phragmites australis* occur in the U.S., two are native and one is an invasive sub-species from Europe dating back to the 1700s or 1800s. The invasive sub-species was likely introduced to the region through ballast water. The sub-species are very hard to tell apart and often require DNA testing to

distinguish them. The invasive sub-species is more common on disturbed habitats such as developed shorelines and forms denser stands than the native species. Seeds of *Phragmites* can be spread by the wind, but an individual plant can also spread by rhizomes, similar to *Spartina*. The tall height of *Phragmites* can shade out shorter native plants, and the dense stands decrease the quality of salt marsh habitat, effectively altering the natural function of the salt marsh-tidal creek ecosystem. Many states have programs to control the spread of *Phragmites*, but it is a constant battle.

Salt marshes and tidal creeks are vulnerable to the ***changing climate*** and ***sea level rise***. When excess carbon dioxide is released into the atmosphere from burning fossil fuels such as coal, oil, and gas, it acts like a heat trapping blanket and causes the atmosphere to warm. This leads to polar ice caps melting and the ocean water warming and expanding, which causes sea level to rise. An increase of a few inches in sea level can result in major changes in plant and animal distribution in the marsh. For the salt marsh platform to survive, the sediment accumulation on the marsh surface and *Spartina* growth must occur at the same pace or faster than the rising sea level. If the marsh surface cannot keep pace, *Spartina* and other marsh plants will drown. The salt marsh will then become open water muddy habitat, with greater potential of erosion. Vegetative buffers on the uplands adjacent to salt marshes can reduce the risk by allowing the salt marsh to migrate back as the sea level rises. In addition, increasing temperature would increase evaporation, which could lead to increased salinity levels in the sediment. Creating open water habitat or increasing sediment salinity levels will change which plant and animal species live in the marsh. We largely do not know what all of the effects will be; however, the salt marsh-tidal creek food web for all life in the marsh, including people, will likely change with a changing climate.

Spartina trapping sediment

Protection and Legislation

Since the 18th century, people have "reclaimed" acres of salt marsh and tidal creek habitat by filling them in with refuse and soil to create dry uplands for agriculture, houses, and other forms of development. Historically, the marsh platform was used as grazing areas for cows. In addition, much of historic Charleston, SC, was filled in during the late 1700s and early 1800s, creating notable downtown areas like the City Market. This practice continued into the 20th century, with little realization of the extent of impact filling salt marshes and tidal creeks has on natural drainage patterns, thus leaving the coastline in a heightened state of vulnerability, particularly during storm events.

In the 1970s, in an effort to regulate future impacts on marshes, Federal and State governments began to develop and implement legislation to protect the remaining coastal wetlands. For the first time, legislation regulated activities that could occur on or in the salt marsh-tidal creek ecosystem. Permits are now required before any new activity can occur. Pieces of legislation identified areas of environmental concern in each state, and developed management strategies that balance use and preservation of the coastal habitat, and regulate the kind of activities allowed on coastal wetlands with the ultimate goal of protecting the salt marsh-tidal creek ecosystem. In 1970, Georgia was the first state to establish coastal wetlands legislation. The Coastal Marshlands Protection Act was developed through the Georgia Department of Natural Resources. The Act led the way for the rest of the Southeast. After the National Coastal Zone Management Act was authorized in 1972, North Carolina established the Coastal Area Management Act of 1974, which is managed by the North Carolina Department of Environment and Natural Resources. In 1977, South Carolina implemented the Coastal Tidelands and Wetlands Act, which is managed by the SC Department of Health and Environmental Control. In 1978, the Florida Coastal Zone Management Act was implemented by the Florida Department of Environmental Program. This last Act rounded out the legislative protection of Southeast marshes and tidal creeks.

What can you do?

Despite the many threats to the salt marsh-tidal creek ecosystem, there are a number of things that you can do to help protect it. Whether you are a homeowner, fisher, or recreation enthusiast, one of the biggest things you can do is to become a steward of our salt marshes and tidal creeks. Salt marshes and tidal creeks provide all of us with benefits that enhance our quality of life through flood protection, pollution control, and seafood production, among others. Here are some actions you can take to do your part to protect the salt marsh-tidal creek ecosystem for you and your community.

Individual

- ***Share your knowledge and appreciation with others!***

- Get involved. Contact a local environmental organization to see how you can volunteer to help protect our salt marshes and tidal creeks.

- Do not litter and participate in local Beach or River Sweep Programs. Litter is an eyesore but can also harm marine life. Scientists are finding that plastics breaking down create microplastics within 8 weeks of entering the marine environment. You may not see microplastics, but they are very harmful to coastal animals.

- Buy a fishing license or fishing stamp even if you do not fish. In most states this money helps to fund research and conservation efforts.

- Make sure to pick up after your pets and dispose of waste properly! Pet waste is full of bacteria which can get washed into the marsh with stormwater runoff.

- Before you fertilize, get a soil test to see what kind of fertilizer you need or if you even need it.

- Follow the label for proper fertilizer and pesticide application. Be mindful of applying before large rain events, unless directed to do so, and store fertilizers and pesticides properly.

- Use water wisely! Do not over irrigate your lawn, and direct rain water to where it can soak into the ground. Install a rain barrel or cistern to collect rain and use it to water plants later.

- Dispose of chemical wastes, such as oil, properly, and recycle whenever possible.

Homeowner

- Contact the state agency responsible for protecting your coastal wetlands (defined in most states as the area below mean high water) before undertaking any activity near or in the marsh. You need to know the regulations and what you can and cannot do.

- Some states, and even specific areas within states, have vegetative buffer requirements. Before altering land adjacent to the marsh, you should check with the appropriate agency.

- Protect an existing vegetative buffer or plant a new vegetative buffer along the salt marsh to filter runoff and reduce erosion.

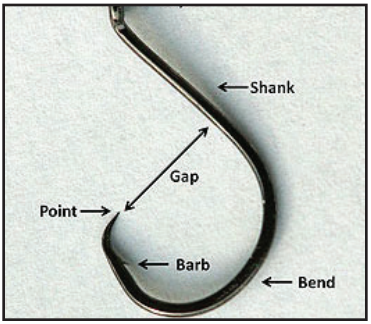
- If you have erosion, consider a **living shoreline** such as marsh grass or an oyster reef instead of a bulkhead or riprap.

- When planting on the upland, consider using native plants which require little irrigation or fertilizer. If you have invasive plants, such as Chinese tallow, dispose of them properly to limit their impact on the ecosystem.

- Minimize the amount of new impervious surfaces by keeping vegetation or using pervious material such as gravel and mulch instead of new concrete.

Anglers

- Know the fishing regulations in your state. Fishing limits are set to protect a species from decline.
- Participate in a volunteer fish tagging program to contribute information on fish species.
- Take steps to release the fish in a healthy condition if you are not planning to eat it.
- Use circle hooks to minimize the impact of the hook, and remove it as soon as possible.
- When using crab traps, make sure to check them every hour and release any diamondback terrapins that may be trapped, since they need to breathe air.
- Crab traps left in the water when you are not fishing for crabs are called "ghost traps." Dispose of these traps responsibly to avoid trapping diamondback terrapins or other animals.



Circle hook


Ghost trap

Sign promoting marsh protection


Blue crab measuring board

Classification

This section provides an overview of the abundance and diversity of life in the salt marsh-tidal creek ecosystem. The classification of organisms is called taxonomy and is based on the morphology and shared characteristics of organisms. The following is by no means a complete list; it is our goal to give you an idea of some of the plants (flora) and animals (fauna) that you may see during your own salt marsh exploration. We also hope you use it as a guide to expand upon through your own research.

Of course, you can take the time to simply look through the information and pictures provided, learning some fun facts about our flora and fauna while you do so. However, we also hope you use this guide as a research tool. For the flora, we focus on two common types of algae found in the marsh and then the main terrestrial plants you will see. For the fauna, we get more specific and have organized our species by phylum. A phylum is a group of related life forms. Specifically, each phylum will represent a group of animals that have a similar body plan. Below is the breakdown of how all living things are organized.

DOMAIN
KINGDOM
PHYLUM
CLASS
ORDER
FAMILY
GENUS
SPECIES

You can see that phylum is close to the top, meaning it is a group encompassing many species. For each phylum we will provide an overview of the characteristics specific to that group. Each individual plant and animal will have its genus and species, referred to as its scientific name, below its common name.

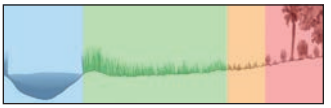
Habitat and Trophic Level

In order for you to better understand where each organism primarily fits in the salt marsh-tidal creek ecosystem food web, as well as where it can *primarily* be found, we have provided some identifying features next to each species' name. For trophic level within the food web, you will see a capitalized letter inside a set of parentheses directly after the common name of the organism.

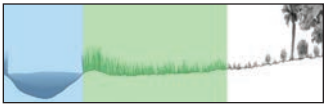
(P) = Producer - creates its own energy
(D) = Detritivore - consumes decaying matter
(H) = Herbivore - consumes plants
(C) = Carnivore - consumes animals
(O) = Omnivore - consumes plants and animals

For location within the salt marsh-tidal creek ecosystem, a cross section diagram is provided to the right of each species' name. The color coded areas of the cross section indicate which zone or zones the organism *primarily* resides in. For example, a fish is designated here as primarily residing in the tidal creek zone; however, many can also be found feeding on the marsh surface at high tide. The colors for each zone are listed below, as well as some examples. For the fauna, you will also see an "**R**" or a "**T**" in the upper left of each cross section indicating whether the animal spends their whole life (**Resident**) or only part of their life (**Transient**) in the salt marshes and tidal creeks.

Blue = Tidal creek
Green = Low marsh
Orange = High marsh
Red = Upland border

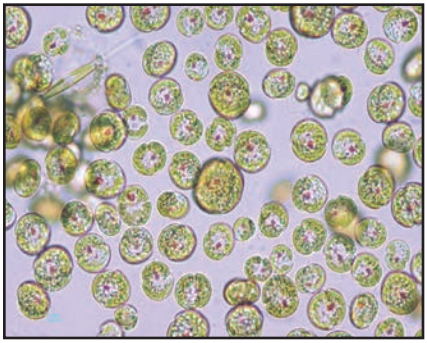


All zones



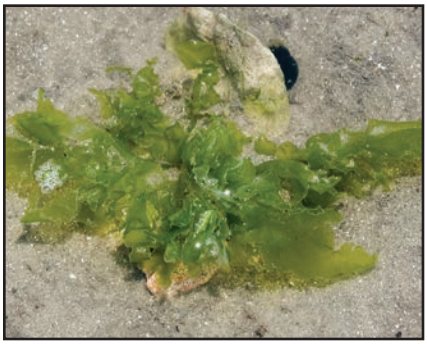
Tidal creek & low marsh

Upland border & high marsh



Phytoplankton (P)

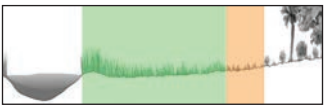
Characteristics: free-floating plants that are mostly unicellular and form the base of the aquatic food chain
Range: worldwide
Size: microscopic
Habitat: fresh and salt water
Fun fact: phytoplankton are primary producers, effectively producing much of the oxygen we breathe on land



Sea lettuce (P)
Ulva lactuca

Characteristics: bright green, sheet-like frond
Range: worldwide in temperate and tropical climates
Size: mats can reach up to 3ft (1m) in width
Habitat: attaches to hard substrate in estuarine intertidal and shallow subtidal zones
Fun fact: used in many personal care, gardening, and fertilizer products

Smooth cordgrass (P)
Spartina alterniflora



Characteristics: slender, flat leaf blades that taper at the tip; leaves are yellow-green in the spring and summer, and brown in the fall and winter

Range: Atlantic coast of the U.S., the Gulf of Mexico coastline, invasive along the Pacific coast

Size: height of grass depends on which zone of the salt marsh it is found in; in the low marsh, *Spartina* can reach heights up to 8ft (2.5m), but in the high marsh it may only reach 1ft (30cm) in height

Habitat: throughout the marsh platform, especially tall along the shoreline of tidal creeks

Fun facts: *Spartina* is the only grass with the adaptations needed to survive in the stressful low salt marsh environment: 1) glands along the blades excrete excess salt, and 2) a root-rhizome system acts as an anchor, holding the grass steady against high wave energy; as salinity decreases it shares space with other species; the stems and root mats of *Spartina* are highly effective at accumulating fine sediment, thus helping combat sea level rise; *Spartina* reproduces in three ways: 1) seeds disperse by wind and tides, 2) fragments of living plants break off and form new ones, and 3) rhizomes can sprout new plants

Black needlerush (P)
Juncus roemerianus

Characteristics: stiff, sharp green-black leaves
Range: MD to FL, the Gulf of Mexico
Size: up to 6ft (2m) in height
Habitat: high marsh towards the upland border, or in elevated spots on the marsh platform
Fun facts: named needlerush because of sharp needle-like points at the end of the leaves; used in sweetgrass baskets

Glasswort (P)
Salicornia virginica

Characteristics: round, fleshy, jointed branches
Range: Atlantic and Pacific coasts of the U.S.
Size: patches range in size
Habitat: high marsh, can colonize bare areas such as salt pannes where other plants cannot survive
Fun fact: edible to humans and harvested as an accent for salads

Marsh elder (P)
Iva frutescens

Characteristics: upland shrub with pointed green succulent leaves
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: 3-8ft (1-2.5m) in height
Habitat: marsh upland border
Fun fact: acts as important nesting habitat for the marsh wren and red-winged blackbird

Saltgrass (P)
Distichlis spicata

Characteristics: thin, slender green leaves
Range: Atlantic and Pacific coasts of the U.S., the Gulf of Mexico, and the northern coast of South America
Size: 1-3ft (up to 1m) in height
Habitat: high marsh towards the upland border, troughs of back dune areas
Fun fact: saltgrass is an important food plant for butterflies

Saltmeadow cordgrass (P)
Spartina patens

Characteristics: long, shiny, dark green leaves
Range: Atlantic coast of the U.S., the Gulf of Mexico, and along the shores of the Great Lakes
Size: 1-4ft (up to 1m) in height
Habitat: marsh platform and sandy beaches
Fun facts: can tolerate fresh, brackish, and salt water; sometimes difficult to distinguish between other upland grasses

Saltwort (P)
Batis maritima

Characteristics: small, fleshy, club-shaped bright green leaves
Range: Southeast U.S. coast, the Gulf of Mexico, and coast of CA
Size: patches range in size
Habitat: high marsh, often near salt pannes
Fun facts: retains salt in its leaves, similar to *Salicornia*; harvested for cooking purposes

Sea lavender (P)
Limonium carolinianum

Characteristics: smooth, green leaves with small light purple flowers
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: up to 1ft (30cm) in height
Habitat: brackish marshes, coastal beaches
Fun fact: flowers are often harvested for floral arrangements; over-harvested in some areas

Sea ox-eye daisy (P)
Borrichia frutescens

Characteristics: leaves are fleshy and gray-green, with yellow flowers
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: 2-4ft (up to 1m) in height
Habitat: upland border in the marsh, sometimes beach dunes
Fun fact: sea ox-eye is an important source of nectar for butterflies; thick leaves help retain water during dry periods

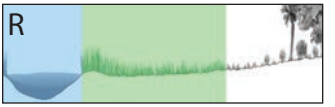
Phylum Annelida

The phylum Annelida includes earthworms, polychaete worms, oligochaetes, and leeches. Worms in this phylum are primarily characterized by having segmented bodies (some worms have more conspicuous segments than others). Except for leeches, all annelids also have hair-like projections, called setae, coming from their body. The worms we will address here are all marine annelids, and are either in the class polychaeta or oligochaeta.

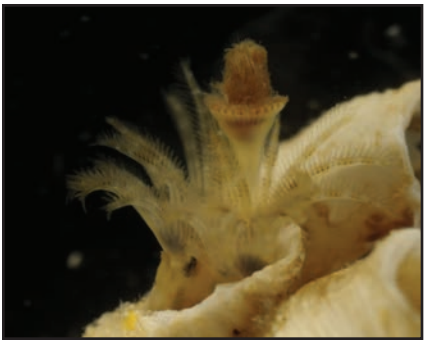
Polychaeta - A polychaete is a worm that has many setae projecting off of its body ("poly" meaning many). Most segments on a polychaete have parapodia, or paddle-like feet, which are used for movement and other functions such as pumping water through burrows. The picture below is an example of parapodia on a polychaete with setae protruding coming from them.

Oligochaeta - An oligochaete is a worm that has fewer and simpler setae projecting out of the body wall. Earthworms are terrestrial oligochaetes. Estuarine oligochaetes are much smaller and generally less than a centimeter long. A high power microscope is often needed to look at the setae of an oligochaete in order to identify it.

Clam worm (O)
Alitta succinea



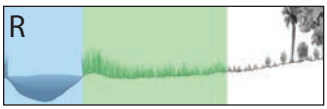
Characteristics: polychaete; head has four large eyes, four pairs of tentacles, and one pair of long palps
Range: Atlantic and Pacific coasts of the U.S.
Size: up to 1.5in (3.5cm) in length
Habitat: estuaries, tidal creeks, marsh platform, sand and mud
Fun fact: worms in this family are highly preferred and sought after by shorebirds



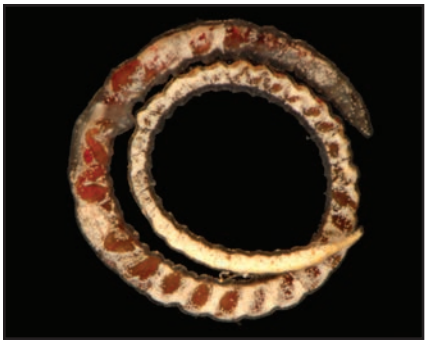
Fan worm (H)
Hydroides dianthus

Characteristics: polychaete; lives in calcium carbonate tube; tentacles protrude for feeding; tube closes with an operculum
Range: Atlantic coast of the U.S., south through the West Indies
Size: less than 0.5in (1cm) in length
Habitat: hard surface in estuaries, such as oyster reefs
Fun fact: known as a fouling organism because of its ability to cover hard surfaces, especially oysters

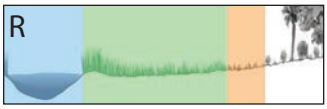
Capitellidae (D)



Characteristics: a polychaete family; bodies tapered at end; loosely coiled; shorter setae, need microscope to identify to species level
Range: Atlantic and Pacific coasts of the U.S., the Gulf of Mexico
Size: less than 0.5in (1cm) in length
Habitat: estuarine flats, marsh platform, tidal creek bottoms
Fun fact: will reproduce during times of environmental stress

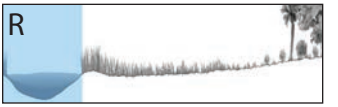


Monopylephorus rubroniveus (D)



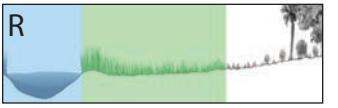
Characteristics: oligochaete; body with numerous segments similar to earthworm; red gut and white coelomocytes (cells)
Range: Atlantic and Pacific coasts of the U.S.
Size: less than 0.5in (1cm) in length
Habitat: salt marsh, tidal creeks, primarily intertidal
Fun facts: very tolerant of stress and pollution, found in areas with high levels of contaminants and **hypoxia**; candy cane appearance

Plumed worm (C)
Diopatra cuprea



Characteristics: polychaete; lives in tube with items attached to it; five antennae; body with branchiae (like gills) behind the head
Range: Atlantic coast of the U.S., and the Gulf of Mexico
Size: up to 5in (12cm) in length
Habitat: mud and sand flats, primarily intertidal
Fun fact: decorated tube (pictured above) is home for other small animals and plants which are sometimes eaten by the worm

***Streblospio benedicti* (H)**



Characteristics: polychaete; head with four eyes and four tentacles; red-brown body; each segment with small parapodia
Range: Atlantic and Pacific coasts of the U.S.
Size: less than 0.5in (1cm) in length
Habitat: estuaries, tidal creeks, marsh platform
Fun fact: feeding typically happens by the tentacles sweeping the surface of the mud to capture fine particles and detritus

Phylum Mollusca

The phylum Mollusca has five classes including chitons, scaphopods, bivalves, gastropods, and cephalopods. Animals in this phylum are characterized by having a soft body with a "head" and a "foot" region, and a mantle that secretes a shell. While these are shared characteristics, different classes of molluscs can look very different from each other. Only three of these classes, bivalvia, gastropoda, and cephalopoda, are commonly found in the salt marsh-tidal creek ecosystem.

Cephalopoda ("head" - "foot") - Squid, octopus, cuttlefish, and nautilus are cephalopods. Except for the nautilus, the shell is greatly reduced and found internally. Eyes are well developed, and arms and tentacles surround the mouth to capture food and bring it towards a sharp beak. Cephalopods will use their siphon to discharge waste and to quickly expel water brought in through the mantle to move.

Bivalvia ("two" - "valves") - This class includes clams, scallops, mussels, and oysters. Bivalves have two shells that are joined at a dorsal hinge by a ligament and teeth. The shells protect the interior soft body of the animal. Bivalves have filtering capabilities, meaning they suck in water and circulate it over the gills for respiration and capturing food. They also filter out pollutants and nutrients, making bivalves important in supporting healthy water quality.

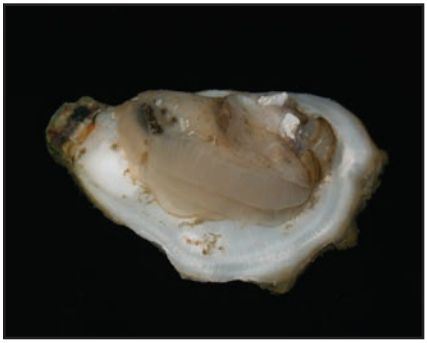
Gastropoda ("stomach" - "foot") - Snails and sea slugs make up the gastropoda class. Snails have only one shell that is continuously secreted from their mantle, coiling around the body. The apex, or top, of the shell is the oldest, with new whorls added as the snails grow. Snails are able to seal their shell closed with their operculum, effectively protecting them from predators or water loss if exposed to the atmosphere. Sea slugs, on the other hand, are gastropods that have reduced shells internally.

Atlantic brief squid (C)
Lolliguncula brevis

Characteristics: cephalopod; body covered in chromatophores; large eyes; arms and tentacles surround mouth and sharp beak
Range: NJ to FL, and northern Gulf of Mexico
Size: up to 5in (13cm) in length
Habitat: estuaries, tidal creeks
Fun fact: internal shell is referred to as the "pen shell" because it is said that sailors used to dip it in ink to write with

Eastern mud snail (D)
Ilyanassa obsoleta

Characteristics: gastropod; black or dark brown conical shell
Range: Native to Atlantic coast of the U.S., now invasive along the Pacific coast
Size: up to 1in (3cm) in length
Habitat: intertidal mud flats
Fun fact: highly active scavengers, swarms of mud snails will break down organic matter on the surface of the mud



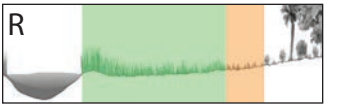
Eastern oyster (H)
Crassostrea virginica

Characteristics: bivalve; shell narrow at the hinge and widening to a rough oval shape; gray exterior with glossy white interior
Range: Atlantic coast of the U.S.
Size: shells average 2-6in (5-15cm) in length
Habitat: tidal creeks, intertidal in Southeast, also subtidal in NC
Fun fact: oyster beds provide important living habitat for many species of fish and invertebrates

Hard clam (H)
Mercenaria mercenaria

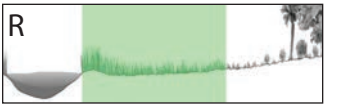
Characteristics: bivalve; thick oval shell with noticeable growth rings and tan exterior color
Range: Atlantic coast of the U.S., the Gulf of Mexico
Size: shells average 2-5in (5-13cm) wide
Habitat: intertidal to subtidal; coarse, shelly sand
Fun facts: most valuable clam harvested in the US; may live more than 40 years

Marsh periwinkle (D)
Littoraria irrorata

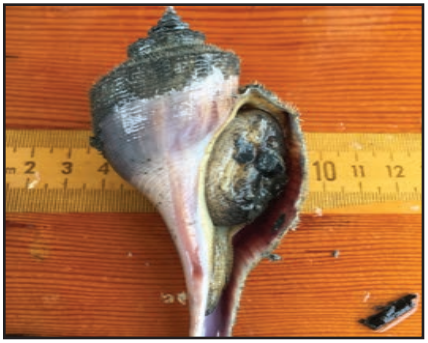


Characteristics: gastropod; shell color dark brown to white
Range: New England to the Gulf Coast of Texas
Size: up to 1in (3cm) in length
Habitat: stalks of living and dead *Spartina*, low marsh to the upland border
Fun facts: feeds on microalgae and detritus, plays a key role in decomposition and the recycling of marsh nutrients

Ribbed mussel (H)
Geukensia demissa



Characteristics: bivalve; thin, long shells with brown, green, or purple exterior and iridescent interior
Range: Atlantic coast of the U.S. until northern FL
Size: shells average 2-5in (5-13cm) in length
Habitat: marsh platform
Fun fact: grows in clusters near the base of *Spartina* plants and holds fast to the plant's roots with byssal threads



Channeled whelk (C)
Busycotypus canaliculatus

Characteristics: gastropod; 5-6 whorls; fine beading toward tip of spire
Range: Atlantic coast of the U.S.
Size: 4-8in (10-20cm) in length
Habitat: sand and mud flats, oyster reefs, offshore to 60ft deep
Fun fact: uses a muscular foot to hold bivalve prey while chipping at its hinge until it can pry the shells apart

Knobbed whelk (C)
Busycon carica

Characteristics: gastropod; shell has an average of 6 whorls with protruding knobs evenly spaced; shell opening on the right
Range: Atlantic coast of the U.S.
Size: 4-10in (4-25cm) in length
Habitat: tidal creeks, often found on oyster reefs, up to 30ft deep
Fun fact: lays a string of egg capsules that can often be found washed ashore

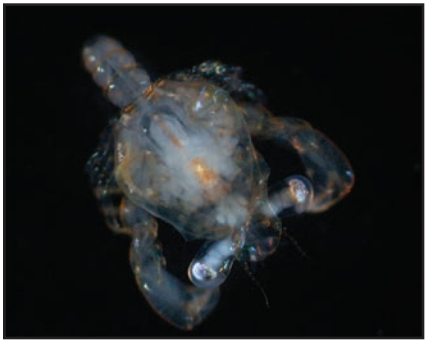
Phylum Arthropoda

The phylum Arthropoda (arthro = "joint"; poda = "foot") includes insects, chelicerates, and crustaceans. Arthropods characteristically have jointed appendages and an exoskeleton, or external skeleton. The body of an arthropod is separated into three regions: head, thorax, and abdomen. These regions are not always distinct, particularly in decapods. Finally, while many insects pass through the marsh, we chose to focus solely on the grasshopper, which directly interacts with *Spartina alterniflora.*

Chelicerata - Horseshoe crabs are divided into three regions: the prosoma (front), the opisthosoma (rear), and telson (tail). Located under the prosoma are 14 appendages; one pair are small pinchers ("chelicerae"), others are walking and pushing legs. Horseshoe crabs must shed their exoskeleton to grow, in a process called molting, and will crawl out the front of their split exoskeleton.

Crustacea - Crustacea is a sub-phylum of Arthropoda which includes a wide ranging group of organisms including **decapods**. Many animals in the order Decapoda ("ten feet") are found in the salt marsh-tidal creek ecosystem, primarily crabs, shrimp, and hermit crabs. Decapods have five pairs of legs on the thorax; in "true" crabs, the first pair are modified into claws used for feeding and protection. While shrimp and hermit crabs have very distinct regions, "true" crabs have a fused head and thorax region called the cephalothorax.

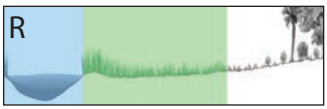
Insecta - Insects are divided into three regions: the head, with a pair of antennae, the thorax with three pairs of legs and usually wings, and the segmented abdomen. Insects in the salt marsh-tidal creek ecosystem aid in decomposition of organic matter and the recycling of nutrients.



Zooplankton (H)

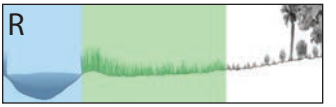
Characteristics: tiny animals in water column with limited mobility, forms link between phytoplankton and larger organisms
Range: worldwide
Size: microscopic
Habitat: fresh and salt water
Fun fact: holoplankton continue as plankton their entire life; meroplankton start as zooplankton and grow into a larger animal

Amphipod (H)



Characteristics: laterally compressed body; species vary greatly in size, shape, and color
Range: worldwide
Size: less than 0.5in (1cm) in length
Habitat: tidal creek intertidal areas in a variety of sediment types
Fun fact: amphipods serve as a critical food resource for many birds and small fish

Atlantic mud crab (O)
Panopeus herbstii



Characteristics: trapezoidal carapace, brown to gray; five teeth behind eye sockets; claw tips black or brown
Range: Atlantic coast of the U.S.
Size: carapace width up to 2.5in (6cm)
Habitat: estuaries up to 70ft (21m) deep, tidal creeks, low marsh
Fun facts: dominant mud crab in salt marshes; capable of crushing small juvenile oysters

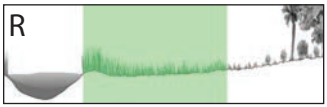
Squareback marsh crab (D)
Armases cinereum

Characteristics: square carapace brown to olive; last segment of the fourth walking leg has black spines
Range: MD to FL and the Gulf of Mexico
Size: carapace width up to 1in (3cm)
Habitat: high marsh, vegetated upland border
Fun fact: often feeds on insects that consume marsh elder leaves, thus reducing herbivory on the plant

Male

Mud fiddler crab (D)
Uca pugnax

"H" depression in middle of the carapace; eyestalks long; Atlantic coast of U.S.; carapace width up to 1.5in (4cm); muddy substrate; males wave large claw to attract females



Female

Sand fiddler crab (D)
Uca pugilator

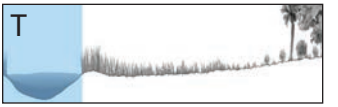
Pink-purple body, purple dot in center; Atlantic coast of U.S. and Gulf of Mexico; carapace width up to 1.5in (4cm); sandy intertidal; bristles on claws remove food bits from sand

Female

Red-jointed fiddler crab (D)
Uca minax

Larger than other *Uca*; red joints on male's large claw; Atlantic coast of U.S., Gulf of Mexico; carapace width up to 1.5in (4cm); low salinity to freshwater; withstands anoxia

Blue crab (C)
Callinectes sapidus



Characteristics: last pair of legs paddle-like for swimming; edge of shell with 9 teeth on each side; four teeth between the eyes
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: carapace width up to 9in (23cm)
Habitat: nearly every type of estuarine and near shore habitat
Fun facts: some harvest regulations differ by state, but all harvested females with eggs must be released

Lesser blue crab (C)
Callinectes similis

Characteristics: similar to *C. sapidus*, but six teeth between eyes (innermost two can be very small); claws tinted with fuchsia
Range: DE to FL and the Gulf of Mexico
Size: carapace width up to 5in (13cm)
Habitat: sand and mud in lower estuaries and tidal creeks with moderate to high salinity
Fun fact: often compete for resources with *C. sapidus*

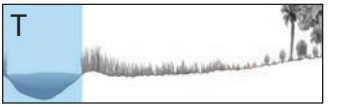
Florida stone crab (C)
Menippe mercenaria

Characteristics: carapace brown to red with light spots; toothed claws often unequal in size, tips black; legs with red bands
Range: NC to FL and the Gulf of Mexico
Size: carapace width up to 6in (15cm)
Habitat: tidal creeks, oyster reefs, sand and mud
Fun facts: claws crush prey, such as oysters; harvest rules vary across states regarding claw harvesting

Thinstripe hermit crab (C)
Clibanarius vittatus

Characteristics: two claws and eight legs, last two designed to cling to an empty shell; brown legs with thin, white stripes
Range: VA to FL and the Gulf of Mexico
Size: hard part of carapace up to 1.25in (3cm) long
Habitat: mud or sand beaches and tidal creek; up to 72ft in depth
Fun facts: hermit crabs retract deep into the shell; as they grow, hermit crabs will select and move into larger shells

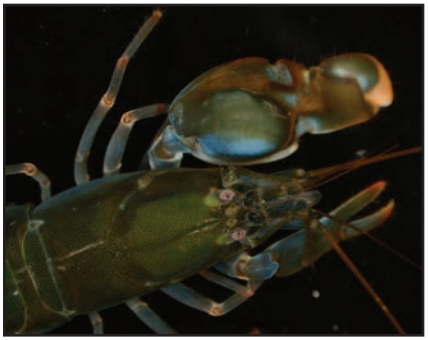
White shrimp (O)
Penaeus setiferus



Characteristics: antennae 2.5–3 times body length; body white with black speckles; eyes kidney shaped
Range: Atlantic coast of the U.S., the Gulf of Mexico
Size: up to 4in (10cm) long in tidal creeks, 4-8in (10-20cm) long in open water
Habitat: transient, estuaries, tidal creeks
Fun fact: more active during the day than brown shrimp

Brown shrimp (O)
Penaeus aztecus

Characteristics: conspicuous ridges that extend the length of the head; brown-green body; eyes kidney shaped
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: up to 4in (10cm) long in tidal creeks, 4-8in (10-20cm) long in open water
Habitat: transient; estuaries, tidal creeks, primarily mud bottom
Fun fact: usually burrow in response to lower temperatures



Big-clawed snapping shrimp (C)
Alpheus heterochaelis

Characteristics: one large chela (claw), with dark translucent green body and a small rostrum (shark projection off the head)
Range: from NC to FL
Size: up to 2.5in (6cm)
Habitat: tidal creeks, common around oyster beds
Fun fact: the large claw can snap and create a loud popping sound that can stun or kill prey

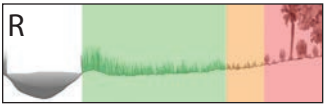
Grass shrimp (O)
Palaemonetes vulgaris

Characteristics: clear shrimp with long rostrum bearing sharp teeth and round eyes at the end of conspicuous stalks
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: up to 2in (5cm) in length
Habitat: shallow estuaries, abundant in tidal creeks
Fun facts: tolerates changing conditions; can be found in waters with salinities ranging from 2 to 36 ppt

Horseshoe crab (C)
Limulus polyphemus

Characteristics: brown carapace; two compound eyes and set of simple eyes on the prosoma; three distinct body regions
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: females 18-19in (46cm) head to tail; males 14-15in (36cm)
Habitat: beaches, tidal creeks, estuaries
Fun fact: horseshoe crabs lack antennae, jaws, and have seven pairs of legs, making them related to spiders and scorpions

Salt marsh grasshopper (D)
Orchelimum fidicinium



Characteristics: similar to common garden grasshopper; green with two long antennae; camouflages very well with *Spartina*
Range: Atlantic coast of the U.S.
Size: averages 1in (3cm) in length
Habitat: among vegetation on marsh platform to upland border
Fun fact: tends to feed on different areas of *Spartina* blades to avoid competition with the periwinkle snail

Phylum Chordata

The phylum Chordata includes thousands of species found worldwide, but this guide will only cover a few classes. First, all chordates share the following four primary characteristics.

1. A **notochord** ("back" - "string"), at least in the embryo stage, that serves as structural support.

2. A **dorsal hollow nerve cord**, which serves to connect the brain and nerves with the rest of the body.

3. **Pharyngeal slits**, essentially openings to the throat. In fish, the slits are their gills, and in humans the slits have been modified as our ears.

4. A **post-anal tail**, or an extension of the body behind the anus. In humans, this gets absorbed before birth.

Since these phylum characteristics cover a wide variety of organisms, it is interesting to note that although two species may look very different, they can still be related. For instance, sea squirts first develop with a dorsal hollow nerve cord, meaning they are more related to humans than a sea slug!

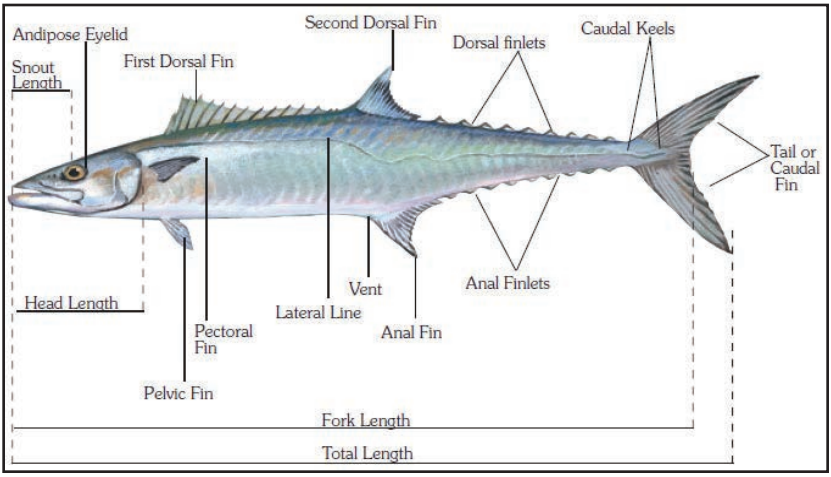
As you read through the chordates in this section you will notice that they are grouped by classes, all of which are found in the subphylum Vertebrata. The following five classes are explored in the guide.

- Osteichthyes (bony fishes)
- Chondrichthyes (cartilaginous fishes)
- Mammalia (mammals)
- Reptilia (reptiles)
- Aves (birds)

Class Osteichthyes

This class is comprised of the bony fish (osteo = "bone"), and has the most species in it of all the vertebrate classes. Bony fishes have rays of gills on both sides of their head, which are covered by an **operculum** ("little door") for protection. This class of fish also has an air sac, or swim bladder, that allows them to control their buoyancy, meaning they can float in one spot without sinking.

Bony fishes come in a variety of shapes and sizes, but most follow a standard body plan regarding fin type and placement. Some fish, like the flounder, may look completely different from a typical fish, but will still have the same fin types. While our diagram below shows you a standard fish body plan, what we would like to highlight particularly is the function of each of the fins.



Dorsal fin: aids in balance, keeping the fish upright
Caudal fin: used for propulsion, to move the fish
Pectoral fin: used for steering and maneuvering around objects
Pelvic fin: helps fish go up and down, helps fish turn quickly
Anal fin: works with the dorsal fin to aid in balance and stability

Bay anchovy (O)
Anchoa mitchilli

Characteristics: small fish with faint silver stripe down sides; out of the water, will usually be lacking scales; dorsal fin originates over the origin of the anal fin
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: up to 4in (10cm) in length
Habitat: coastal ocean to the upper reaches of tidal creeks
Fun fact: main source of nutrition for the endangered least tern

Atlantic silverside (O)
Menidia menidia

Characteristics: looks similar to anchovy except smaller mouth; conspicuous silver stripe down side of body; pointed snout
Range: Atlantic coast of the U.S.
Size: up to 5in (13cm) in length
Habitat: sandy shorelines, estuaries and tidal creeks
Fun facts: sensitive to environmental changes, such as depleted oxygen; absence can be used as an indicator of poor water quality

Striped killifish (C)
Fundulus majalis

Characteristics: silver sheen on sides; females with long stripes and a couple of bars near the tail; males have 15-20 bars
Range: Atlantic coast of the U.S.
Size: up to 6-7in (17cm) in length
Habitat: tidal creeks and beach shallows
Fun facts: not as common as mummichog but also play a large role in estuary food webs, prey for most birds and fish in marsh

Mummichog (O)
Fundulus heteroclitus

Characteristics: small brown-green fish with pale spots along the body; males are brighter with bars along the side
Range: Gulf of St. Lawrence to Gulf Coast of Texas
Size: up to 6in (15cm) in length
Habitat: resident in tidal creeks, sometimes in freshwater
Fun fact: "mummichog" comes from an Indian word meaning "going in crowds," referring to its common schooling behavior

Atlantic croaker (C)
Micropogonias undulatus

Characteristics: silver with faint dark bars on sides; faint black spot above pectoral fin
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: up to 20in (51cm) in length
Habitat: estuaries, tidal creeks to several miles offshore
Fun fact: make a loud croaking sound by vibrating the swim bladder

Black drum (C)
Pogonias cromis

Characteristics: deep-bodied, silver to dark gray with black tinted fins; lower jaw with barbels extending down; large scales
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: averages 14in (36cm) in length
Habitat: live bottom in estuaries, rare in tidal creeks, beaches; often near hard structures such as jetties and docks
Fun fact: use their barbels to sense for food along the bottom

Red drum (C)
Sciaenops ocellatus

Characteristics: bronze or red colored with one or more dark spots near tail fin
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: up to 4-5ft (1.5m) in length
Habitat: nearshore, estuaries, tidal creeks
Fun facts: spot on the caudal fin is used to distract predators; most caught estuarine drum are sexually immature

Silver perch (C)
Bairdiella chrysoura

Characteristics: silver body with yellow fins, anal fin has prominent spine; dorsal fin has a deep notch
Range: NY to FL, the Gulf of Mexico
Size: up to 9in (23cm) in length
Habitat: shallow estuarine waters, primarily tidal creeks
Fun fact: will often make loud drumming sounds with their swim bladder when caught

Southern kingfish (C)
Menticirrhus americanus

Characteristics: long, silver body with 7-8 bars on sides; fins yellow; small mouth with a single short barbel on chin
Range: Cape Cod to northern Argentina
Size: averages 6-10in (15-25cm) in length
Habitat: estuaries, along beaches and near mouths of rivers
Fun facts: most abundant of three kingfish species in SC; not frequently seen in tidal creeks

Spot (C)
Leiostomus xanthurus

Characteristics: silver-blue dorsal and silver-yellow ventral; 12-15 bars along sides; spot behind operculum, above pectoral fin
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: up to 10in (25cm) in length
Habitat: shallow muddy bottoms of estuaries, tidal creeks, often around oyster reefs
Fun fact: larvae develop offshore then move into the estuaries

Spotted seatrout (C)
Cynoscion nebulosus

Characteristics: dark gray dorsally with black spots along the body; two large teeth on the tip of the upper jaw
Range: NY to the Gulf of Mexico
Size: up to 30in (76cm) in length
Habitat: inshore live bottom habitats in estuaries and tidal creeks
Fun fact: delicate fish, care should be taken when returning unwanted fish to the water

Pinfish (O)
Lagodon rhomboides

Characteristics: similar to spot; sharp dorsal and anal spines along fins; spot behind operculum; six bars run along the sides
Range: Atlantic coast of the U.S., Bermuda, the Gulf of Mexico, northern Cuba, and the Yucatan
Size: averages 7in (18cm) in length
Habitat: nearshore reefs, estuaries, tidal creeks
Fun fact: consume both vegetation and animals

Atlantic menhaden (O)
Brevoortia tyrannus

Characteristics: blue color with silver sides and forked tail; black spot behind operculum with several small spots near it
Range: Nova Scotia to FL
Size: up to 15in (38cm) in length
Habitat: offshore along the continental shelf and in estuaries
Fun facts: main source of nutrition for dolphins and large fish because of their high oil content; major component in fish meal

Bay whiff (C)
Citharichthys spilopterus

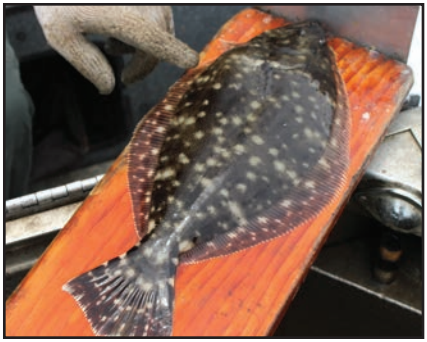
Characteristics: flat body with both eyes on left side; spots are small, if present, and in no particular pattern
Range: NJ to the Gulf of Mexico, and from the Antilles to Brazil
Size: up to 6in (15cm) in length
Habitat: estuaries, sandy and muddy habitats
Fun facts: mistaken for a juvenile flounder; can be identified by its straighter lateral line

Blackcheek tonguefish (C)
Symphurus plagiusa

Characteristics: small flatfish with no obvious tail; posterior ends in a point; large dark spot on operculum
Range: NY to the Gulf of Mexico, the Bahamas, and Cuba
Size: up to 7in (18cm) in length
Habitat: estuaries, tidal creeks, primarily over soft mud
Fun fact: from head to the tail the tonguefish is smooth, but reverse directions and it becomes very rough

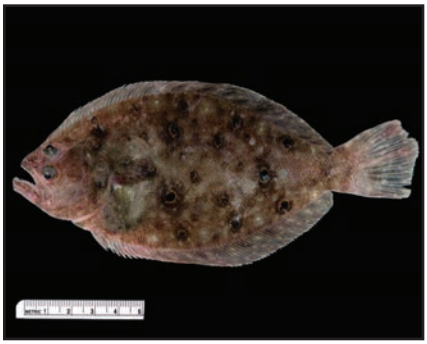
Hogchoker (C)
Trinectes maculatus

Characteristics: small flatfish with round body; noticeable stripes; black bars along dorsal side; ventral side with light spots
Range: Atlantic coast of the U.S. and the Gulf of Mexico
Size: up to 6in (15cm) in length
Habitat: shallow to deep estuarine waters over sand or mud
Fun fact: name thought to come from farmers who would feed this to their hogs, which would often choke on them



Southern flounder (C)
Paralichthys lethostigma

Characteristics: flat body with both eyes on left side; dorsal color varies with habitat; spots and blotches
Range: VA to FL and the Gulf of Mexico
Size: averages 15in (38cm) in length
Habitat: estuaries, beach shallows, muddy bottom of tidal creeks
Fun facts: most abundant flounder species in the Southeast; most return to the same estuaries after spawning offshore



Summer flounder (C)
Paralichthys dentatus

Characteristics: flat body with both eyes on left side; dorsal color varies with habitat; five conspicuous spots
Range: Atlantic coast of the U.S.
Size: averages 15in (38cm) in length
Habitat: estuaries and tidal creeks over sand or mud
Fun fact: flounder start off as typical fish larvae, with an eye on either side of the body, but transform into a flat fish

Sheepshead (C)
Archosargus probatocephalus

Characteristics: body compressed laterally; gray with dark bars alongside the body
Range: Nova Scotia to Brazil
Size: up to 30in (76cm) in length
Habitat: estuaries, tidal creeks, near hard structure such as docks
Fun fact: hard mouth has several rows of stubby teeth which help the fish scrape prey off of structures and crush the shells

Atlantic spadefish (C)
Chaetodipterus faber

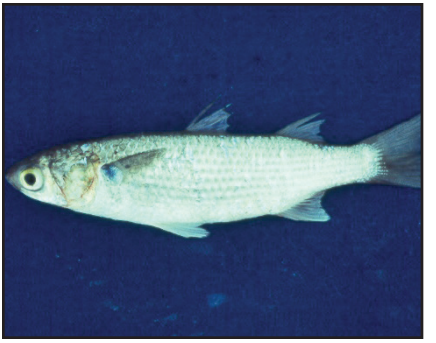
Characteristics: silver-gray to yellowish; disc shaped body; 4-6 vertical black bars on sides; small mouth
Range: Atlantic coast of the U.S., Gulf of Mexico, Southeast Brazil
Size: 12-18in (30-46cm) in length
Habitat: estuaries, tidal creeks, hard bottoms like oyster reefs
Fun fact: juveniles leave estuaries during fall and join adults in shallow offshore waters

Striped burrfish (C)
Chilomycterus schoepfi

Characteristics: round yellowish body with dark, wavy stripes; head and body covered with short spines; dark spots at base of the dorsal fin and behind pectoral fins
Range: Atlantic coast of the U.S., and the Gulf of Mexico to Brazil
Size: up to 10in (25cm) in length
Habitat: seagrass beds, shallow reefs, tidal creeks
Fun fact: puffs up its body into a spiny ball to avoid predators

Oyster toadfish (C)
Opsanus tau

Characteristics: scaleless; brown with orange to yellow spotting; wide head; large mouth; many barbels; eyes on top of head
Range: Atlantic coast of the U.S. to the West Indies
Size: 8-12in (20-30cm) in length
Habitat: estuaries, tidal creeks, bottom-dwelling near oyster reef
Fun fact: should be handled carefully, they have strong jaws and stiff spines in fins



Striped mullet (H)
Mugil cephalus

Characteristics: slightly darker above, silver on sides, dark spot at base and stripes on side
Range: worldwide
Size: up to 3ft (1m) in length, usually less than 20in (50cm) in the Southeast
Habitat: estuaries, tidal creeks
Fun facts: often jump out of the water, occasionally lands in boats

White mullet (O)
Mugil curema

Characteristics: long silver body with dark dorsal coloring
Range: Atlantic coast of the U.S., Bermuda, Gulf of Mexico to Brazil, and from the Gulf of California to Chile
Size: up to 14in (36cm) in length
Habitat: estuaries, tidal creeks
Fun fact: mullet are omnivorous but primarily get their nutrition from plankton, algae, and detritus

Class Chondrichthyes

This class comprises the sharks, rays, skates, and chimaeras. In the salt marsh-tidal creek system you will find a few different species of sharks and rays. They are characterized by having jaws and a skeleton made of cartilage, like what our ear lobes are made of, instead of bone. Instead of having an operculum covering their gills, sharks and rays have 5-7 visible gill slits on the sides of their head. Unlike bony fish, the cartilaginous fish do not have a swim bladder, so must move continuously or else they will sink.

One characteristic unique to cartilaginous fishes is the ampullae of Lorenzini. If seen, the ampullae will look like small dots around the mouth or nose of a shark or ray. They are actually sensory cells that are able to detect small electric charges given off by their prey. These animals are not naturally aggressive, but when walking through a tidal creek it may be a good idea to do the "sting ray shuffle" to warn them that you are coming!

Atlantic stingray (C)
Dasyatis sabina

Characteristics: disk-shaped, flat body, dark gray or light brown above and lighter below; snout is elongated
Range: NJ to the Gulf of Mexico
Size: up to 2ft (0.5m) in disk width
Habitat: shallow estuaries, tidal creeks
Fun fact: spiracles on the top are often mistaken for another set of eyes but they actually take in water while buried in sediment

Atlantic sharpnose (C)
Rhizoprionodon terraenovae

Characteristics: streamlined body, gray dorsally and white ventrally; nose comes to a point, anal fin originates slightly in front of the second dorsal fin
Range: Atlantic coast of the U.S. to the Gulf of Mexico and Brazil
Size: up to 3.5ft (1m) in length
Habitat: surf zone of sandy beaches and into estuaries
Fun fact: juveniles have black edges on dorsal and caudal fins

Bonnethead (C)
Sphyrna tiburo

Characteristics: shovel-shaped head with eye on either side; gray-brown dorsally and white ventrally; mouth on the bottom
Range: Atlantic coast of the U.S. to Brazil, and CA to Ecuador
Size: up to 4ft (1m) in length
Habitat: warm estuaries, often in tidal creeks
Fun fact: females move further into shallow water than males do, but scientists do not yet understand why

Class Mammalia

This is the class most recognizable to us as this is the class humans belong in! Mammals, just like fish, can come in a variety of shapes and sizes, but they all share the same five characteristics.

1. All mammals have **fur or hair**; some, such as the dolphin, only have hair at birth which eventually falls out.

2. Female mammals all have **mammary glands** that produce milk.

3. Mammals are all **warm-blooded** animals, meaning they regulate their body temperature internally ("endothermic").

4. All mammals will give birth to **live young**; the platypus is the odd one out, it lays eggs, but shares all other characteristics with mammals so it is put in its own separate subclass within mammalia.

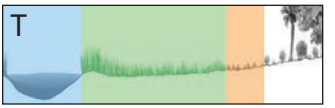
5. All mammals have **lungs** and breathe air; even though dolphins can stay underwater for a long time, they still must come to the surface eventually to take a breath.

Many mammals in the salt marsh are quick and elusive, particularly the mink and the otter. Bottlenose dolphins, however, frequent the Southeast's estuaries and tidal creeks and can usually be seen easily from boat or dock. Although many mammals appear friendly and look approachable, it is important to remember they are wild animals. You should not touch or feed them and they should be viewed from a distance. Legislation, such as the Marine Mammal Protection Act, outlines appropriate viewing distances for a number of mammals and the penalties associated with interacting with them. This protection is for both the animal and the human.

Bottlenose dolphin (C)
Tursiops truncatus

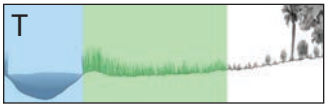
Characteristics: gray body with large head and defined beak; dorsal fin triangular; flukes pointed and deeply notched
Range: worldwide, tropical to cold-temperate waters
Size: inshore groups up to 6ft (2m) in length
Habitat: deep estuaries to shallow tidal creeks
Fun fact: propel themselves and their prey out of the water during strand feeding, often seen along banks of tidal creeks

Mink (C)
Mustela vison



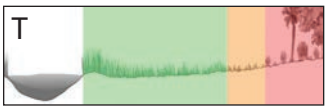
Characteristics: short legs and long tail; brown fur with white markings under chin; tip of tail is darker than the rest of the body
Range: North America except southwest and most northwest
Size: 19 – 28in (48-71cm) in length
Habitat: tidal creeks, swamps, rivers, ponds
Fun fact: mink are polygamous and can often be aggressive in their courtship

North American river otter (C)
Lontra canadensis



Characteristics: streamlined body with brown fur and long tapered tail; prominent whiskers below the nose
Range: throughout North American waterways
Size: average 4ft (1m) in length
Habitat: lakes, freshwater wetlands, salt marshes, tidal creeks
Fun fact: powerful musk glands produce a pungent scent, used to communicate with other otters

Raccoon (C)
Procyon lotor



Characteristics: gray and black with a distinct black banded tail; conspicuous ears stand straight up; band of black covers the eyes
Range: throughout the U.S.
Size: up to 3ft (1m) in length
Habitat: variety of habitats, in the marsh from platform to upland
Fun fact: do not truly hibernate in cold weather, will hide and become inactive

Class Reptilia

The class Reptilia is comprised of the snakes, turtles, crocodiles, and lizards. Reptiles have dry scales and most will lay eggs on land. They are also ectothermic, meaning their body temperature is regulated by its environment. It is important to note that while their body temperature is dependent on the environment, reptiles can control it in some ways. For instance, you will often see reptiles sunning themselves, but you may also see them lying in the shade, allowing them to exert some control over internal body temperature.

While you may see some different reptiles around the marsh upland border, we decided to focus solely on the two primary reptiles that you will see while you are exploring the lower salt marsh and tidal creeks. These reptiles are the American alligator and the diamondback terrapin, both charismatic, well known species. The alligator is not often seen in saltwater, but that does not mean that you never will. They are primarily found in freshwater environments but will move through saltwater tidal creeks.

The diamondback terrapin is readily seen in the salt marsh, although usually one will only see its head poking out of the water before it quickly dives back down. It is unique in that it is the only pond/marsh turtle that can survive in a high salinity environment without access to a freshwater source. Females will only leave the tidal creeks when it is time to lay her eggs. If you see a diamondback terrapin on the road or in a parking lot, it is recommended you move it to safety, but keep it facing the same direction it was originally heading.

Diamondback terrapin in a tidal creek

American alligator (C)
Alligator mississippiensis

Characteristics: rounded snout with black and yellow/white body color; may only see tip of snout and eyes above water line
Range: NC to FL and the Gulf of Mexico
Size: 10-14ft (3-4m) in length
Habitat: coastal wetlands, primarily freshwater with suitable nesting and feeding grounds
Fun fact: bellow and slap their heads on water to communicate

Diamondback terrapin (C)
Malaclemys terrapin

Characteristics: diamond shaped pattern on carapace; black, gray, brown, or spotted body; males much smaller than females
Range: Cape Cod to FL and the Gulf of Mexico
Size: females reach 6-7in (17cm) in length; males reach 4-5in (11cm) in length
Habitat: estuaries, tidal creeks, can survive in high salinity
Fun fact: hibernate in the mud in winter and mate in the spring

Class Aves

This class is for the birds! Birds have scales on their feet, and feathers, which are just modified scales, covering their body. Birds lay eggs that require incubation and have hollow bones, allowing even large birds to weigh only a few pounds. Birds also have the best vision of all the vertebrates. The number of birds that frequent the salt marsh is extensive, so we decided to group the birds into four basic groups.

Birds of prey: Birds of prey, also called raptors, are any predatory bird that hunts and feeds on larger animals, such as mice, reptiles, fish, and other birds. Raptors have a hooked beak, sharp talons, and exceptional vision that allows them to see prey on the ground during flight.

Songbirds: Songbirds are known as "perching" birds, as their feet are specifically adapted to grip a perch, like a small branch. True to the name, they are well-developed vocally; each will have unique calls or songs. These songs are used for various communications. Most birds have a song solely for courtship.

Seabirds and Shorebirds: A seabird is any bird that spends most, if not all, of its life in the marine environment and has adapted to interact with, and get its nutrition from the ocean. A shorebird is any bird that frequents the shoreline; they generally have long legs and slender bills to probe sediment for prey. Gulls, terns, and skimmers have similar traits and behaviors, so are grouped together.

Wading birds: Wading birds can be found in fresh and saltwater habitats. On the coast, they are most often seen in tidal creeks, feeding along the creek banks, near oyster reefs, and on mud flats. They have long, thin legs to help them walk across soft, unstable mud, their bills are usually long and designed to probe soft sediments for prey, and their necks are usually long and sinuous.

Birds of Prey

American bald eagle (C)
Haliaeetus leucocephalus

Brown body; white head, neck, and tail; North America; 70-90in (2m) wingspan; nests in tall trees along shorelines; white plumage will not develop until eaglet is at least three years old

Osprey (C)
Pandion haliaetus

Brown with white speckled breast, dark stripe across eyes; North America, Alaska, south to Chile; 55-70in (1.5m) wingspan; dense, oily plumage allows deep dives for prey

Red-tailed hawk (C)
Buteo jamaicensis

Brown plumage above, white below; belly streaked with brown; North America; 48in (1.25m) wingspan; builds nest with sticks and conceals it between branches of a tree

Songbirds

Belted kingfisher (C)
Megaceryle alcyon

Blue dorsally with white spots; females with red band on belly; North America; 23in (58cm) wingspan; nests on banks; courting males will feed females

Marsh wren (C)
Cistothorus palustris

Small brown, gray body; upturned tail; streaks on head and above eye; North America coasts to Mexico; 5in (13cm) wingspan; hides in marsh grass; heard more than seen

Red-winged blackbird (C)
Agelaius phoeniceus

Males black with red and yellow spot on wings; females brown with red chin; throughout U.S.; 16in (41cm) wingspan; fresh and salt marshes; commonly seen in small flocks

Saltmarsh sparrow (C)
Ammodramus caudacutus

Yellow face, gray patch over ear; Atlantic coast of the U.S. and upper Gulf of Mexico; 7in (18cm) wingspan; salt marsh; nests often washed away by extreme tides

Seabirds and Shorebirds

American oystercatcher (C)
Haematopus palliatus

Black heads with white breast; long, red bill; U.S. coasts; 35in (1m) wingspan; sand and mud flats near oyster reefs; form long-term bonds with mate

Brown pelican (C)
Pelecanus occidentalis

Head white, brown down the neck; long bill with pouch (gular); NC to FL and Gulf of Mexico; 78in (2m) wingspan; removed from endangered species list in 2009

Clapper rail (C)
Rallus longirostris

Thin with long legs and large feet; black and white bars on sides; U.S. coasts to Peru and Brazil; 21in (53cm) wingspan; construct canopy over nests to conceal; very secretive

Double-crested cormorant (C)
Phalacrocorax auritus

Black with yellow beak; long neck; North America; 48in (1m) wingspan; fresh and coastal waterways; will stand on banks with wings spread to dry

Seabirds and Shorebirds

Black skimmer (C)
Rynchops niger

Lower bill longer; white belly; red legs; U.S. coasts, Caribbean, Gulf of Mexico; 42-50in (1.25m) wingspan; estuaries, beaches, shell bars; skims jaw on water surface to feed

Laughing gull (C)
Leucophaeus atricilla

Orange bill, gray body; Atlantic coast of U.S., Gulf of Mexico to South America; 47in (1m) wingspan; frequents beaches, marshes, landfills; has a loud characteristic laughing-like call

Least tern (C)
Sternula antillarum

White head and forked tail; orange bills with black tips; Atlantic coast of U.S.; 20in (51cm) wingspan; estuaries, beaches and sandbars; shakes water on eggs to cool them

Royal tern (C)
Thalasseus maximus

Orange bill; gray body and black feathers on cap; coasts of U.S., Atlantic coast of Africa; 53in (1.25m) wingspan; estuaries, beaches; mating pair can find their chick in a crowd

Wading Birds

Black-crowned night heron (C)
Nycticorax nycticorax

Black back; robust, pointed bill; North, Central, and South America; 47in (1m) wingspan; salt and fresh wetlands; will take care of any chick

Yellow-crowned night heron (C)
Nyctanassa violacea

White stripe behind eyes; yellow on crown; Southeast, Central to northern South America; 45in (1m) wingspan; wetlands; forages 15ft from other birds

Green heron (C)
Butorides virescens

Dark green back, gray wings; U.S. coasts, Central America to northern South America; 27in (69cm) wingspan; swamps, marshes, reservoirs; creates lures to entice small fish

Wading Birds

Great blue heron (C)
Ardea herodias

Blue-gray, black stripe over eye; North and Central America to the northern tip of South America; 80in (2m) wingspan ; salt and fresh marsh; weighs 5-6 pounds

Little blue heron (C)
Egretta caerulea

Body with purple tint; yellow eyes, black tip on bill; Southeast interior and coast, Central and South America, Caribbean; 41in (1m) wingspan; "teeth" on toe to groom their plumage

Tricolored heron (C)
Egretta tricolor

Dark with red tint, white belly; long yellow legs; Atlantic coast of the U.S., Central to South America, Caribbean; 37in (1m) wingspan; coastline habitats; will use foot to stir up sediment

Wading Birds

Great egret (C)
Casmerodius albus

White plumage, orange bill; southeastern U.S., southern Canada; 57in (1.5m) wingspan; fresh and salt marsh; mainly eats fish, but may eat amphibians, reptiles, and small mammals

Snowy egret (C)
Egretta thula

Bright white plumage with black legs and yellow feet; North America and most of South America; 39in (1m) wingspan; competes for breeding areas through loud noise displays

Roseate spoonbill (C)
Ajaja ajaja

Pink body, white head; spoon-shaped bill; long pink legs; SC to FL, Gulf of Mexico, tropics in Central and South America; 50in (1.25m) wingspan; sweeps bill back and forth to feed

Wading Birds

White ibis (C)
Eudocimus albus

Curved red bill; red legs; black wing tips; southeast U.S., Gulf of Mexico, Central America; 36in (1m) wingspan; salt and fresh marshes; mudflats and grass fields; nests and feeds in groups

Glossy ibis (C)
Plegadis falcinellus

Brown body; bill curved; Atlantic coast of the U.S., Gulf of Mexico, Central and South America, Africa; 36in (1m) wingspan; marshes, swamps, rice fields; probes soft mud with bill

Wood stork (C)
Mycteria americana

White; black edges on wings and tail; head and neck naked; SC to southern South America; 60in (1.5m) wingspan; habitat alteration put them on endangered species list

Glossary

Abiotic - physical properties of an environment

Adaptation - a change in an organism allowing it to be better suited to live in its environment

Anaerobic respiration - type of respiration not involving oxygen use

Anoxic - almost no oxygen present

Ballast water - fresh or salt water held in ships to increase stability, ships fill tanks in one location and release water in a different location

Barrier island - an island off the coast that protects the mainland

Bateau boat - a light flat-bottomed boat

Best Management Practices (BMP) - a way to reduce the impact of non-point source pollution on waterways

Biotic - the living things in an environment (plants and animals)

Blue carbon - carbon removed from atmosphere by coastal plants and sediment and stored in coastal ecosystems

Brackish - mixture of freshwater and seawater

Decomposition - the process of breaking down naturally

Detritus - leftover organic matter after decomposition (e.g. small pieces of decomposing marsh grass)

Dike - a wall put in place to prevent flooding and control water flow

Ecosystem - a system formed by the interaction between and among organisms and the physical environment

Erosion - gradual wearing away of something by wind or water

Estuary - the area where a river meets the ocean, resulting in a series of mixing zones from freshwater (0 ppt) to full strength seawater (36 ppt)

Eutrophication - excess nutrients in the water

Greenhouse gases - gases that trap heat in the atmosphere

Halophyte - salt tolerant plants

High marsh - upper zone of the salt marsh with infrequent flooding

Hypoxia - oxygen levels low enough to stress organisms

Impervious surfaces - material that water cannot penetrate such as roofs, roads, and parking lots

Impoundment - an enclosed body of water

Intertidal - an area submerged at high tide and exposed at low tide

Invasive species - organisms not naturally found in an area which often compete with and become more abundant than native species

Invertebrate - an animal lacking a backbone

Keystone species - a species that plays a vital role in shaping an ecosystem

Living shoreline - the use of plants, sand, oyster shell, and other organic material to stabilize a bank, thus protecting it from erosion

Low Impact Development - utilizes on-site treatment of stormwater in an environmentally conscious way such as infiltration

Low marsh - lower zone of the salt marsh flooded for most of the day

Monoculture - the presence of only one plant in an area

Mud flat - intertidal habitats with no plants, occurring in areas with weaker currents and muddy sediments

Native - originally found or naturally occurring in an area

Niche - a species' role in an ecosystem

Non-point source pollution - pollution which cannot be traced to a specific source but comes from multiple sources

Non-target organisms - an organism not meant to be caught

Nutrients - substances such as Nitrogen and Phosphorous, required for growth and reproduction, that runoff of nearby land into local waterways

Oyster reef - a large colony of oysters in the intertidal or subtidal habitats

Operculum - a hard lid or flap that covers and protects (e.g. gill cover)

Pluff mud - very fine muddy sediment in the tidal creek and low marsh zones that one can sink in

Refuge - an area which provides shelter and protection

Resident - an organism that spends its whole life in the salt marsh-tidal creek ecosystem

Salt panne - area in the high marsh with high salinity and sandy sediments

Sand flat - intertidal habitats occurring in areas with stronger currents and sandy sediments

Sea level rise - an increase in sea level due to the melting of land ice

Semi-diurnal - occurring twice a day

Sequester - to take away and store something

Shell midden - an area where empty oyster shells were piled by local tribes

South Atlantic Bight - Cape Hatteras, NC to West Palm Beach, FL

Stormwater runoff - water that runs off the land into local waterways

Transient - an organism that spends only part of its life in the salt marsh-tidal creek ecosystem

Turbidity - the cloudiness of the water related to sediment levels

Upland border - transition zone between the high marsh and uplands where plants must be able to tolerate some salt

Vegetative buffer - generally undisturbed vegetation zone between development and salt marsh or estuary

Water quality - a measure of water properties such as turbidity, oxygen, and nutrient levels often used to relate to organism health

Wetland - marsh or swamp area that is always or frequently wet

Wrack - broken off stems of *Spartina alterniflora* that move with the tide and accumulate in mats

Periwinkle snails at base of Spartina stems

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Gullah Geechee Cultural Heritage Corridor:
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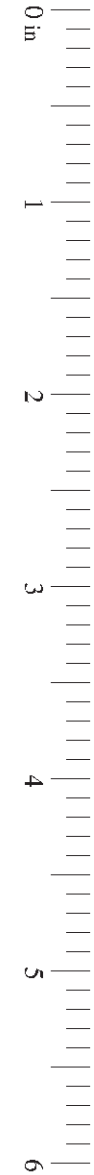

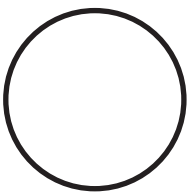

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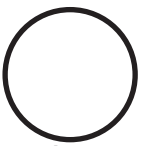

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