Cape Lookout National Seashore

Life on the Outer Banks

An Educator's Guide to Core and Shackleford Banks

Tenth Grade Edition

Prepared by the

Core Sound Waterfowl Museum and Heritage Center

Funded by a grant from the

National Park Service

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Parks as Classrooms

The National Park Service's ***Parks as Classrooms*** program is a nationwide initiative to encourage utilization of the resources of America's national parks for teaching and learning. A visit to the National Park Service's homepage (http://www.nps.gov) reveals a myriad of learning opportunities available to our nation's students and teachers. Students will discover history and explore nature within the context of a changing world; and yet, within the boundaries of many parks, the hands of time are frozen to allow them a "snapshot" of the past. ***Parks as Classrooms*** focuses on bringing learning to life through hands-on, experiential opportunities that are student-friendly, field based, exciting and promote a sense of stewardship of park resources.

Cape Lookout's Classroom

Lying just east of the North Carolina mainland are the barrier islands that compose the famed Outer Banks. Cape Lookout National Seashore protects 56 miles of the southern-most sections of this barrier island chain. The park covers the long, narrow ribbon of sand running from Ocracoke Inlet in the northeast, to Beaufort Inlet in the southwest. These barrier islands are 56 miles long and consist mainly of three habitat zones: wide, bare beaches with low dunes covered by scattered grasses, flat grasslands bordered by dense vegetation, and large expanses of salt marsh alongside the sound.

Under the park's protective watch, habitats rich with a diversity of flora and fauna thrive. The waters surrounding the park are nurseries and feeding grounds for marine mammals and sea turtles, while spring and fall migrations bring many different species of birds. Shackleford Banks is home to a population of wild horses whose lineage can be traced back for hundreds of years to Spanish horses. No less diverse than the animal life are the plant species which have adapted to this harsh and constantly changing environment and flourish within the constant struggle against wind and sea.

Although Core Banks and Shackleford Banks are free of the intrusions of paved roads, resort facilities, and bridges to the mainland, vestiges of the Banks' rich human history are still clearly evident. From Portsmouth—one of the earliest trading ports in North Carolina—to the family graveyard on Shackleford Banks, students gain an understanding of the men and women who carved out a unique lifestyle along the shores of Core, Back, and Pamlico Sounds. Anchoring the entire story of human struggle along the Banks is the more than 150 year old Cape Lookout Lighthouse. Its presence denotes aspects of a lifestyle lived close to and in harmony with nature's elemental forces.

The Classroom Guide

This activity guide is one of a series to help teachers prepare their students for a visit to Cape Lookout National Seashore. Integrated within the science and social studies activities of the guide are selected narratives to give the teacher background information on this unique region of North Carolina. In addition to pre-visit, on-site and post-visit activities, the guide contains poems and songs of the region as well as alternate activities to spark a student's imagination and stimulate problem-solving skill development. Teachers are encouraged to contact the Cape Lookout National Seashore, Division of Interpretation, 131 Charles Street, Harkers Island, NC 28531 (252-728-2250) to schedule visits for their classes.

Acknowledgements

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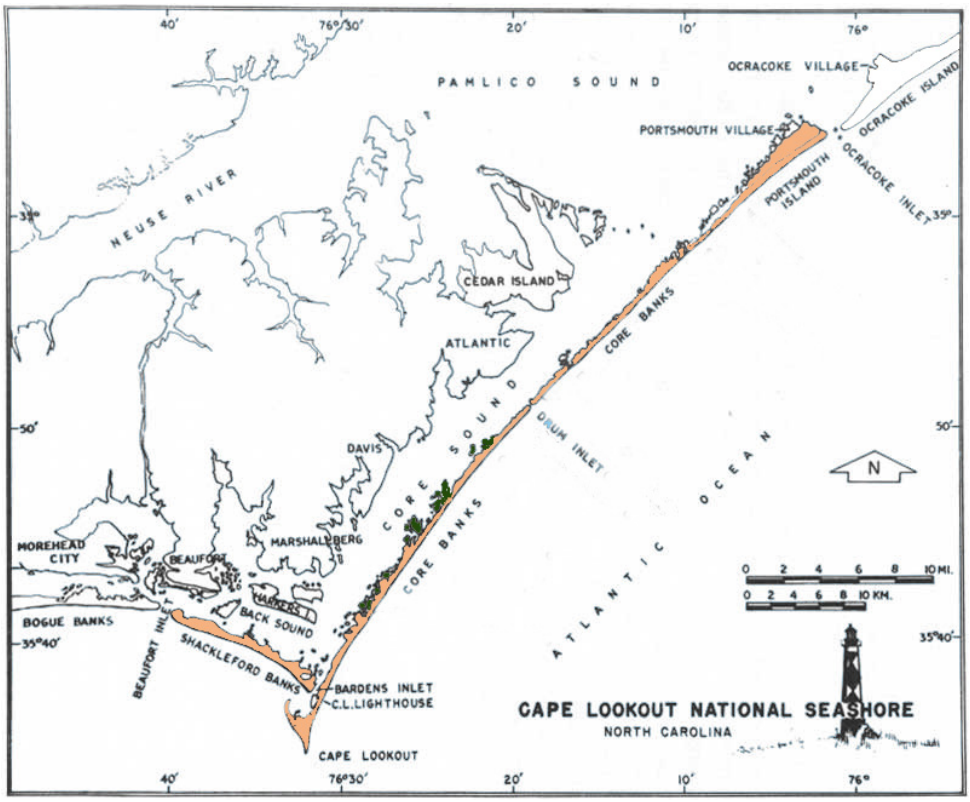


Introduction

The barrier islands of Cape Lookout National Seashore—the southern stretch of the North Carolina Outer Banks—are some of the last remaining natural, undeveloped barrier islands in the world. While these islands are constantly changing, the National Seashore consists of three main islands that are relatively stable: North Core Banks, which includes Portsmouth Village at the northern end; South Core Banks, which includes the Cape Lookout Lighthouse and Cape Lookout Village Historic District at the southern end; and Shackleford Banks, the former site of Diamond City and Wades Shore, and the current home of the Shackleford horses.

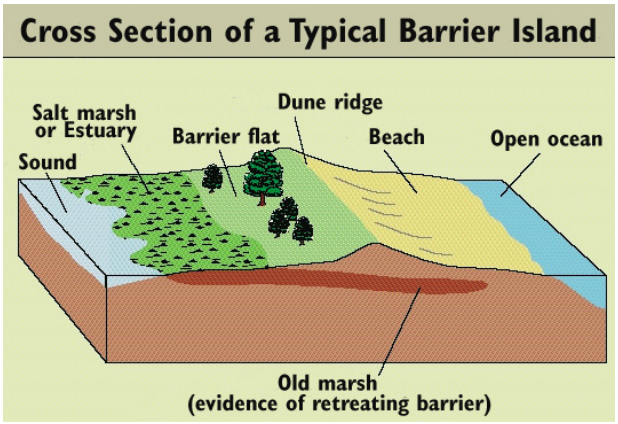
Although uninhabited today, the Cape Lookout National Seashore was home to many people over the years. These islands, also called banks because they formed a border along the coast of North Carolina, were used as temporary fishing encampments by the Coree Indians, a tribe belonging to the Algonquian family. In his 1965 thesis, *Colonial Beaufort*, historian Charles L. Paul noted, "Before white settlers entered the area, the *Coree* had two villages. One of these was located on the north side of the Straits of Core Sound which separates Harkers Island from the mainland, a location not more than seven miles east of the present site of Beaufort or more than eight miles north of Cape Lookout. Later, the islands were used by maritime communities engaged in a variety of subsistence activities such as fishing, whaling, and trading. Having been granted permission in 1726 to whale off the coast of Shackleford Banks, New England whalers Samuel, Ephraim and Ebenezer Chadwick, began the whaling industry in the Cape Lookout area which continued for one hundred and ninety years. Best known to local historians is the establishment of the whaling community of Diamond City on Shackleford Banks.

At its peak, Diamond City was a thriving year-round community of as many as 500 residents. A series of storms in the early 1900s drove many "Bankers" to the mainland or more sheltered islands. Little evidence remains today of this once thriving island community.

In the 1950s the state of North Carolina began purchasing land in the Core Banks area in order to establish a park, but realized by the early 1960s that they did not have the resources to maintain the park. The U.S. Congress authorized the establishment of a national park in this area in 1966. The North Carolina government transferred its property on Core Banks including Portsmouth Island to the federal government in 1974. Shackleford Banks was added in 1985, and is a proposed wilderness area. Today, the Cape Lookout National Seashore covers 56 miles of beach and over 29,000 acres of land and water—protecting the natural and cultural heritage of these islands for generations to come.

Life on the Outer Banks – 10th Grade Edition Science Lessons
Salt Marsh Flora and Fauna

To best work with data you will collect while here on the barrier islands, you must first understand a little about the geography, history, migration and diversity of organisms that make up this fascinating microcosm we call Cape Lookout National Seashore!



What is a Barrier Island?

The barrier islands of Cape Lookout National Seashore formed as a result of thousands of years of geological processes involving the uplifting of the Appalachian Mountains, erosion of mountain rock, transporting of the rock as sand to the ocean, deposition of sand on the continental shelf, and the melting and formation of glaciers which result in the rise and fall of sea level. Barrier islands are called such because they create a barrier between the open ocean and the mainland, protecting the mainland coastline from wind, waves, tides, currents, and storms such as hurricanes. They shelter estuaries that form behind the islands. They also allow marshes to build up in the quiet waters of the sound.

"Here at the water's edge, where the land meets the sea with marsh and shoal, sandy beaches and muddy bottom, is where life begins for all coastal people."
Karen Willis Amspacher, from *"The Spirit of the Tidewater Community"*

Geography of Core Banks

Core Banks consists of three main islands that are relatively stable: North Core Banks, South Core Banks, and Shackleford Banks. Primary focus will be given to the island of Shackleford Banks which is approximately 9 miles long and 1/4 to 1/2 of a mile wide. It is the southernmost island of Cape Lookout National Seashore and is two to five miles off the coast of the mainland, near Beaufort and Harkers Island, NC.

Shackleford Banks is a fairly typical barrier island, based on the information above, but it has changed dramatically since the turn of the 20th century. "It was formerly wooded in its entire length; this woodland, covering about 1250 acres, probably was composed chiefly of live oak, red cedar, yaupon holly and loblolly pine. The inner sound-side shore, on the eastward half of the island, was bordered by salt marshes" (Engles 1952). Today, the maritime forest (a forest near the ocean) is confined to the sound side of the island on the west end.

Although currently uninhabited, Shackleford Banks once supported fish camps and small communities of fishermen and whalers. It was also home to a relatively large number of cattle, horses, sheep, goats, and pigs. These animals were semi-feral, meaning that they were often

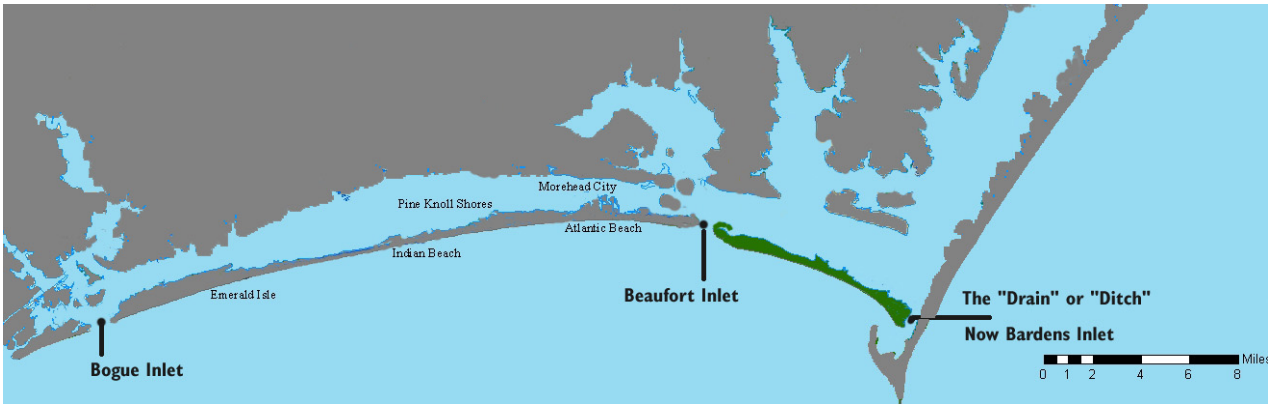
owned, and may have been fed and watered, by people who lived on the island, but they were allowed to roam free. Today, only the horses remain as a wild population.

Like most barrier islands, the location of Shackleford Banks makes it vulnerable to major weather events. Northeasterly storms (called Nor'easters) and hurricanes, which on average impact North Carolina once every four years, can have dramatic impacts on the island. Two of the most damaging hurricanes to hit Shackleford Banks struck in August of 1899 and September of 1933. The 1933 hurricane opened an inlet between Core Banks and Shackleford Banks which was the former location of North Carolina's only whaling community, Diamond City, which had been devastated by the 1899 hurricane. Survivors of that hurricane moved the remaining homes to the Promise Land region of Morehead City or to nearby Harkers Island. (Barnes 1995)

Inlets

The channel of water between adjacent barrier islands is known as an inlet. Inlets can be short-lived features created when water breaches across an island after a large storm such as a hurricane or a Nor'easter. They can also be longer lasting and provide a regular exchange between the sound or estuary and the open ocean: a gateway for a host of marine life and for boat traffic.

The boundaries of Shackleford Banks as a barrier island are currently defined by the Atlantic Ocean, Back Sound, and two inlets: Beaufort Inlet on the west end and Barden Inlet on the east end. Prior to the hurricane of 1933, Shackleford was connected to Core Banks by what was locally called "The Drain" or "The Ditch". This was a low spot about 6 feet wide that during high tide, flooded with about a foot of water. This low spot did not stop human or animal traffic from crossing almost unhindered between Core and Shackleford Banks before 1933.



However, after the storm of September 1933, an inlet formed between Core and Shackleford Banks in the area of the ditch. This new inlet was found to be advantageous for the commercial and recreational fishing fleets, allowing them to access the ocean more quickly and readily. Locals successfully petitioned the state to keep the new channel open by dredging, the removal of sand from under the water's surface. Senator Barden led the project, and so the inlet was named for him in gratitude for his assistance.

The 1888 map shows Shackleford Banks without Barden Inlet. The 1966 map shows the inlet.

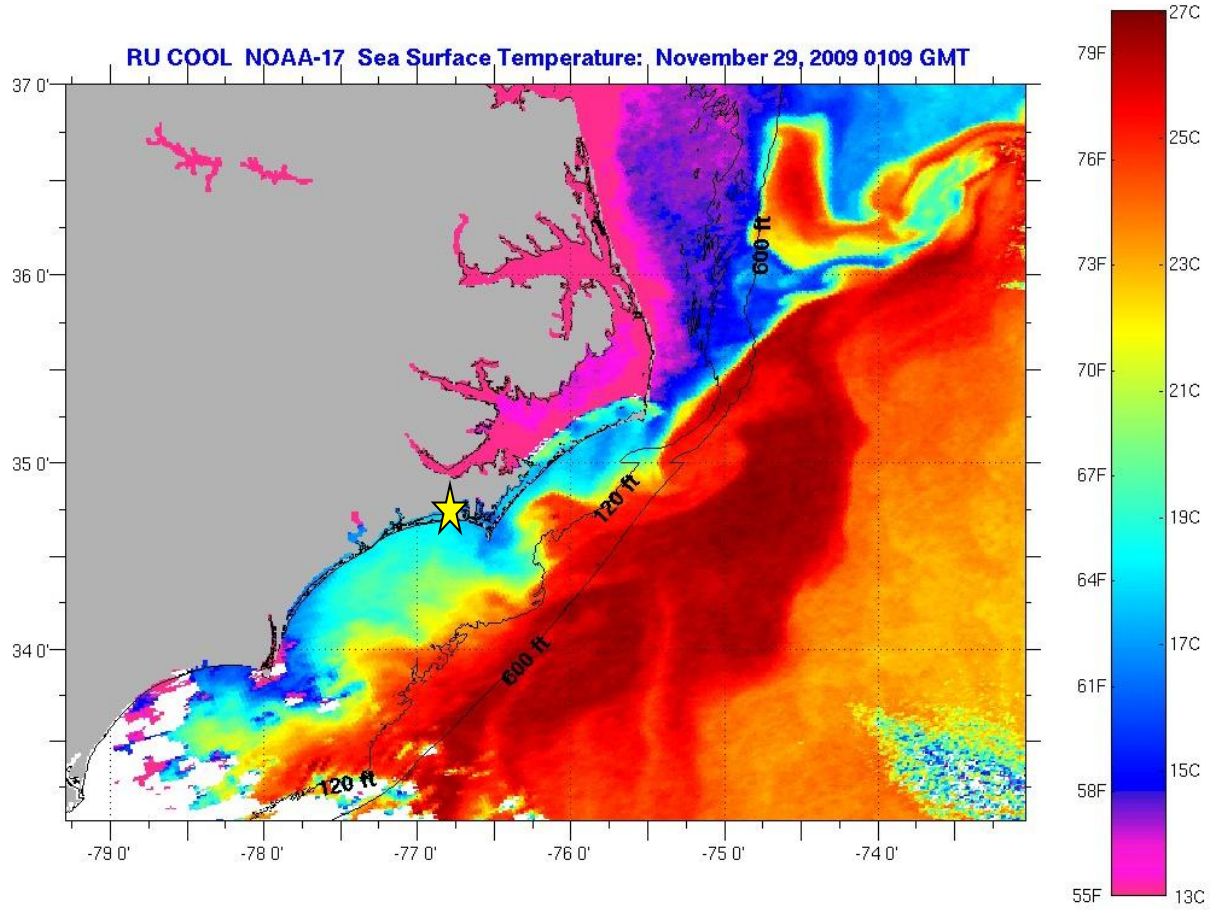
The Plants and Animals of Core Banks

Cape Lookout is centrally located along the coast of North Carolina. It is home to a diverse array of animal and plant life due to the mild climate, the confluence of the Labrador Current and Gulf Stream, the geographic location along the North Atlantic flyway, and the intermingling of fresh and salt water in the vast estuary that forms behind the islands.

Ocean Currents

Near Cape Lookout warm water flowing north along the Gulf Stream meets cold water flowing south from the Labrador Current. The intersection of these two distinct masses of water creates a unique diversity of flora and fauna along the Coast of North Carolina. Both northern and southern species of fish, invertebrates, plant life, marine mammals, and birds reside in the waters off Cape Lookout.

The map below shows the water temperature off the North Carolina coast during the month of November in 2009. Warmer water is shown in red or orange and cooler water is shown in blue and pink. Morehead City is marked with a star.



For more sea surface temperature maps go to: http://marine.rutgers.edu/mrs/sat_data/?nothumbs=0
Rutgers University Sea Surface Temperatures

Diversity

The mixing of warm tropical currents and the colder Labrador Current brings a great deal of diversity to the Southern Atlantic coast, and accordingly, when studying the flora and fauna for this region, identification guides are needed for two regions: North Carolina to Brazil and North Carolina to Greenland. Some examples of the diversity of species in North Carolina can be found in the vegetation: bayberry plants and wax myrtles are present along our coast. Bayberry is a northern species and wax myrtle is a southern species. During the summer, it is not unusual for tropical fish, such as angelfish and sergeant majors, to visit the waters of Cape Lookout. Also, manatees—southern marine mammals—are occasionally seen in the summer and harbor seals—northern marine mammals—can be seen here at other times of the year. The diversity of plants and animals of Cape Lookout, in addition to its miles of undeveloped habitats, make Cape Lookout National Seashore a wonderful place to observe wildlife.

Another reason for the rich diversity of Cape Lookout is the wide variety of habitats that are present along this stretch of barrier islands. There are large expansions of ocean beach, marsh, and sound, as well as upland habitats like maritime forest, dunes, and even freshwater ponds, all sustaining a variety of organisms on these islands.

Migration

These butterflies were found on small red cedar trees on the backside of a dune at Cape Lookout. They were on their fall migration south to Mexico.

In addition to resident plants and animals that have adapted to survive in the challenging marine environment, many animals use the Cape Lookout area habitats as migration layovers or destinations. Butterflies, hundreds of ducks, shorebirds, fish, loggerhead sea turtles, green sea turtles, and various species of whales are just some of the animals that visit during the year.

The waters surrounding Cape Lookout National Seashore are feeding grounds for marine mammals and sea turtles. Four sea turtle species—loggerhead, green, Kemp's ridley, and leatherback—are sometimes seen feeding in area waters. Only the loggerhead sea turtle regularly nests on the park's beaches during the summer months. Sometimes, green sea turtles or leatherback sea turtles will nest here, too, but Kemp’s ridley sea turtles are only found in the water.

Loggerhead sea turtle hatchlings

Common tern

Birds are the most easily observed animals at Cape Lookout. In addition to a large resident population of birds, spring and fall migrations bring a number of different species through the area. Stormy weather can also drive a few pelagic birds in from the open ocean for a visit.

The beaches and dunes of the Cape Lookout National Seashore are nesting areas for many species of birds, including the threatened piping plovers and extreme high priority shorebirds such as the black skimmers, least terns, common terns, and American oystercatchers. Other common shorebirds seen feeding in the surf include willets, sanderlings, and ruddy turnstones.

Mammals are common on the islands; rice rats, rabbits, river otters, and raccoons are some of the native species found here. On Shackleford Banks, there is a population of wild horses that have adapted to their environment over the past few hundred years.

Rice rat

Although salt and brackish water environments dominate the islands, a few fresh water habitats support tree frogs and Fowler's toads. Diamond-back terrapins prefer the salt marsh areas, and the grasslands are the ideal habitat for five-lined racerunner lizards and black racer snakes.

The Cape Lookout Bight area and Shackleford Banks have large dunes, and it is at Shackleford that you will find the most extensive maritime forest in the park. Vines are abundant and are often competing with the trees for sunlight. The changing geography of the island produces the strange and beautiful "ghost forests" on the ocean side of the groves: trees killed by advancing sand dunes and salt spray leave their sun-bleached “skeletons” protruding from the sand.

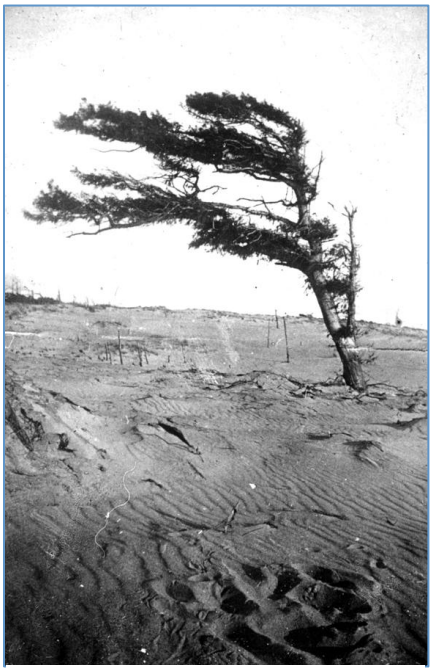
Maritime Forest on Shackleford Banks

The Dead Forest

A severe hurricane struck Shackleford Banks in 1899, causing salty ocean water to wash over most of the island. Most of the trees in the island's forest were killed by the flood waters. Many residents decided that it was unsafe to live on Shackleford and, within three years, the island was deserted. Many residents relocated to Harkers Island.

Because this storm killed so much of the vegetation, there was nothing to stabilize the island. Later storms were able to blow the loose sand from the ocean side of the island to the sound side. The moving sand covered and killed the few remaining live trees. As the sand moved on, it uncovered these dead forests full of the "ghost trees" which had been stripped of their leaves. Today, less than five percent of the island contains a maritime forest.

Skeletons of trees killed by encroaching sand.



Sand and salt spray can twist trees into unusual shapes.

"The active dunes, the rich maritime forest, and the productive salt marsh on Shackleford Banks are extremely valuable for ecological and physiographic studies. Adding to its isolation and small size, the island is a unique ecosystem for scientific investigations and should be set aside as an example of the natural ecosystem of the Outer Banks for the benefit of generations to come—generations who have no voice in present decisions. Shackleford Banks is one of those precious natural features" (Engles 1952).

The Salt Marsh

Teachers in the salt marsh adjacent to Barden Inlet at Cape Lookout

On the sound side of the island, whether it is along Core Sound, Back Sound, or Barden Inlet Cape Lookout Seashore has a marvelous marsh system that plays an important role in the life of the island. There are nearly 200,000 acres of salt marsh along the North Carolina coast. Salt marshes form in regions between the terrestrial and marine environments. Marshes serve as nurseries to a wide variety of organisms, some of which are notably threatened or marketed as important fisheries species.

The dominant plant in many of our coastal marshes is Spartina, a tall cordgrass. There are two predominant varieties. One is smooth cordgrass, scientifically named *Spartina alterniflora,* found in the lower elevations of the saltmarsh. The other variety is *Spartina patens*, or commonly called saltmeadow cordgrass, which is found at higher elevations of the marsh. It is still covered at times by high tides. Specialized cells are able to exclude salt from entering the roots, preventing the loss of fresh water. This grass, however, is less tolerant of saltwater than some other marsh grasses. Both of these grasses are adapted for harsh environmental conditions including flooding, desiccation and extreme temperature and salinity fluctuations. Additionally, the dense web of these cordgrass stems and roots holds the tiny grains of clay and silt in the marsh soil together helping to control erosion and grow the shoreline. The grasses absorb energy from waves and tides that hit the shore which also helps control erosion. Of the local marsh plants, only smooth cordgrass is adapted to both the salinity and tidal fluctuations of the low tidal marsh. According to Teal and Teal (1983) the root membranes prevent the entry of much salt into the plant, and the cells within it absorbs sodium chloride to maintain osmotic pressure. Special glands on the leaves excrete excess salt. Ducts in the stems carry oxygen to the roots of the plant where it is used to turn iron sulfides in the marsh mud into soluble iron compounds that can be used by the plant. The high iron requirement of smooth cordgrass is one of the factors that restricts it to the salt marsh (Adams 1993).

Glasswort (crustaforum.com)

A second plant common to the saltmarsh is known as Glasswort (*Salicornia spp)*. Glasswort is found throughout the marsh, mixed in with cordgrass or on the mud flats. Glasswort grows low to the ground (rarely over 2 feet tall) and has short fleshy green spikes that extend from a main stem. Three species are found in coastal marshes, one of which turns pink in the fall. Glasswort is also called sea pickle and is an edible water storing plant. Glasswort concentrates the toxic salt in its branch tips and then turns brown and falls off. (Witherington 2011)

An important, yet often overlooked animal in the salt marsh, is the ribbed mussel. The shell of a ribbed mussel is shaped like a long round corrugated triangle. Ribbed mussels are usually found partially buried in a muddy or sandy substrate. They anchor themselves with byssal threads, which are mucous strands attached from the mussel to the substrate. Gills aid a pair of siphons to bring water into the mussel. These gills are lined with cilia, which remove oxygen from the water, and trap plankton and organic matter. As the mussel processes the food, inorganic material is recycled back into the mud. This concentrated inorganic material helps to enrich the surrounding mud and contributes to salt marsh growth. Ribbed mussels play an important role in the salt marsh as filter feeders by removing bacteria, heavy metals, and toxins from the water column. More importantly, ribbed mussels exhibit a cooperative relationship with other plants and animals of the marsh. In particular, mussels establish habitat within the root structures of smooth cordgrass and provide essential nutrients that enhance the plants. Ribbed mussel beds also provide support and better stability for the root structures of smooth cordgrass allowing the plants to withstand harsh storm or ice conditions (De Flores 2008).

Experimental removal and addition of mussels in marsh habitats has demonstrated that mussels stimulate both aboveground and belowground *Spartina alterniflora* production. Mussel density is positively correlated with increased grass height, biomass, and flowering of the Spartina cordgrass. (Bertness 1984)

Biodiversity plays a role in the marsh environment. Biodiversity is defined as the quantity of plant and animal species found in a given environment. Biodiversity changes over both distance and time. Biodiversity that varies from place to place is called 'variation over distance'. Variations between years or seasons are called 'variations over time'. (eco-online/novascotia) We must remember therefore, that any data collected creates a mere snapshot of the life in that salt marsh for a given set of conditions under which it was collected.

With this background information it is the hope of the Cape Lookout National Seashore and the Core Sound Waterfowl Museum and Heritage Center, that as teachers you will be able to come to Cape Lookout National Seashore and provide your students with meaningful interactions with the sound and beaches you find here.

Life on the Outer Banks – 10th Grade Teacher Edition
Salt Marsh Flora and Fauna – Life and Lingo Research
Pre-Site Visit Science Activity

North Carolina Essential Standards Biology

Bio.2.1 Analyze the interdependence of living organisms within their environments.
Bio.2.1.3 Explain various ways organisms interact with each other (including predation, competition, parasitism, mutualism) and with their environments resulting in stability within the ecosystem.

Description:

Students will explore some organisms that are associated with the sounds and marshes of Cape Lookout National Seashore, including the North Carolina state shell, the Scotch Bonnet.

Vocabulary: The student will define all terms and use a minimum of 10 terms in their Prezi presentation, to be expanded upon later in the activity.

Abiotic Factors	**Ecosystem**	**Pacing (as a measurement)**	**Quadrat**
Adaptation	**Habitat**	**Perimeter**	**Substrate**
Biodiversity	**Hummock**	**Predator**	**Transect**
Community	**In-situ**	**Prey**	
Desiccation	**Intertidal**	**Profile**	

Fiddler crab (*Uca pugnax*)

Materials:
Computer and Library access including Prezi technology
List of organisms common to Cape Lookout National Seashore
Life History Rubric
Food Web

Pinfish (*Lagadon rhomboides*)

Directions:

1. Students will choose an organism commonly found in or near the marshes and sounds surrounding Cape Lookout National Seashore from the attached list or from their research.
2. Students will conduct library or internet research on their selected organism. Remind students to include:
    a. Basic anatomy/body arrangement and structure/Growth/Behaviors
    b. Habitat
    c. Predators
    d. Prey / Food
    e. Adaptations
3. Students will create a life history presentation of the organism using the online presentation software-Prezi. Prezi.com provides a full tutorial on how to use it. This program is very user friendly.
   The Prezi should include a variety of pictures, a food web for their specific organism, and at least one video clip (school appropriate/teacher approved) that shares one aspect of the life of their organism. This is in addition to specific information listed in #2.
4. To ensure complete information is shared, students will also use Microsoft Office to create a brochure about their organism which they will provide to other class members.
5. Student should use the rubric provided to ensure thoroughness of her/his research.
6. Teacher may wish to establish grade values tied to the 20 possible points students can earn.

Life on the Outer Banks – 10th Grade Teacher Edition
Salt Marsh Flora and Fauna – Life and Lingo Research
Pre-Site Visit Science Activity

Handout # 1-

Marsh Periwinkle	Marsh Crab	*Spartina patens*	Pinfish
Fiddler Crab	Sea Urchin	Sand Dollar	Flounder
Ribbed Mussel	Hermit Crab	Tube Worm	Raccoon
Clam (Quahog)	Blue Crab	Egret	River Otter
Oyster	Outer Banks King Snake	Ibis	Rice Rat
Sunray Venus	Shrimp	Mallard Duck	Marsh Rabbit
Mud Snail	Anole	Mullet	Nutria
Glasswort	*Spartina alterniflora*	Black Needle Rush	Wax Myrtle

Suggested Reference Guides:
Porter, Hugh J. and Lynn Houser. Seashells of North Carolina. Raleigh, NC: North Carolina Sea Grant College Program, 1997.

Witherington, Blair and Dawn. Living Beaches of Georgia and the Carolinas. Sarasota ,Fl: Pineapple Press, Inc., 2011

SAMPLE Food Web for Prezi: **Food web may be modeled using words/pictures or both**

Scotch Bonnet

How to Interpret:
Algae are consumed (eaten by) Sand Dollars and Sea Urchins, which in turn are consumed by Scotch Bonnets, which are consumed by Stone Crabs

Cape Lookout Science Life and Lingo Research Rubric

Researcher: _____
Date: _____

Life History of the _____

As you investigate your organism, find as many answers as you can to the questions below. Some of the questions may not fit with your animal's life history.

Be sure to give thorough information to each question. For example, if your organism hatches from an egg, find out how long it takes to hatch, what is the size and color of the egg, etc.

5 4 3 2 1	a) Anatomy Growth Behavior		How does your organism start its life? (hatch from an egg? live birth? tended by a parent?) Does your organism look very different when it is young compared to how it looks as an adult? (Does it go through a larval stage?) Did you describe the adult animal? Does your organism have unusual or interesting behaviors?
5 4 3 2 1	b) Habitat		Does your organism have a different habitat at different times in its life cycle? Does you organism's habitat change because of tides or seasonally? (tidal zone? migration?) Does your organism live in a habitat that is usually constant, or in a habitat that is constantly changing? (in the waves?)
5 4 3 2 1	c) Food/Prey d) Predators		Did you explain what your organism eats, how it finds its food, and how it eats? What animals will eat or harm your organism? What does your organism do to defend itself or avoid being eaten? How does your organism move to catch prey or to avoid being caught?
5 4 3 2 1	e) Adaptations		What adaptations give your organism a better chance for survival? Does your organism depend on camouflage or mimicry to capture its prey or to avoid being eaten?
5 4 3 2 1	f) Prezi Presentation		Does your Prezi include a Food Web for your organism? Does your Prezi include a video clip as well as a variety of pictures? Is your information presented thoroughly? Does your Prezi make smooth pathway transitions? Did you speak loudly, slowly and clearly?

	Total Points	

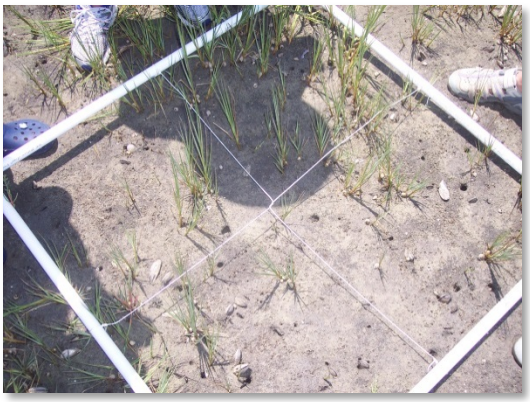
Life on the Outer Banks – 10th Grade Edition
Salt Marsh Flora and Fauna Sampling in the Salt Marsh
On-Site Science Activity

North Carolina Essential Standards Biology

Bio.2.1 Analyze the interdependence of living organisms within their environments.
Bio.2.1.3 Explain various ways organisms interact with each other (including predation, competition, parasitism, mutualism) and with their environments resulting in stability within the ecosystem.

Description:

Introductory information has pointed out plants and animals that occupy the salt marshes along North Carolina's coast and in particular the salt marshes of Core Sound within the Cape Lookout National Seashore. Students will investigate the specific relationships between smooth cordgrass, and ribbed mussels, and glasswort.



Materials:

1 Meter Quadrats – stored on site at Cape Lookout
Clipboard and pencil
Data Sheet

Directions:

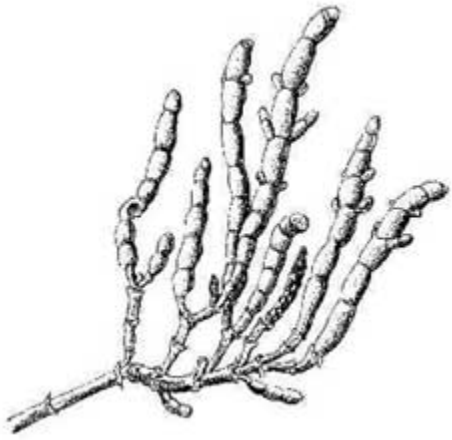
1. Students will get into groups of 2- 4 people. (Groups of 4 is most efficient- but divide up as class size dictates)
2. For a random sampling of data, groups should spread out throughout the marsh.
3. At each sampling site, a member of each group will randomly toss the one-meter quadrat onto the ground within the study area and adjust the strings to create four equal sampling sections (quadrants).
4. Using the data sheet provided herein, and beginning in the top left corner of each appropriate quadrant, each group member records the number of ribbed mussels,

glasswort and cordgrass plants within their designated area. This data should be tally numbers as well as location placement within the quadrant.

Images of the 3 organisms students will observe:

Cordgrass:

Glasswort:



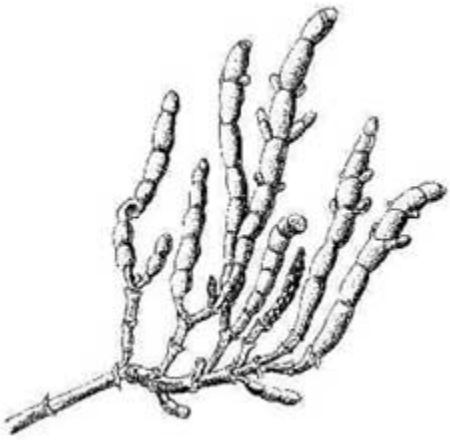
Ribbed Mussels:

Salt Marsh Flora and Fauna Sampling in the Salt Marsh
On-Site Science Activity

Handout #1: Student Image Referral Sheet

Cordgrass:

Glasswort:



Ribbed Mussels:

Salt Marsh Flora and Fauna Sampling in the Salt Marsh
On-Site Science Activity

Handout #2: Student Quadrant Data Sampling Sheet

A	B
C	D

Investigator(s)**:**_____

_____

_____

This data sheet is for Quadrant Letter _____

1. Use tally marks to record the number of each species observed**:**

Ribbed Mussels	Glasswort Plant	Cordgrass Plants

2. Place the location of the species observed in your samples in the quadrant diagram below using the following symbols:

R- Ribbed Mussels **G- Glasswort** **C- Cordgrass**

	R CC C **GG RR** **CCC** **GG** **GG** **G G** **R R** **R R**

YOUR DATA **SAMPLE**

Salt Marsh Flora and Fauna Sampling in the Salt Marsh
Post Site Science Activity

Handout # 3: Student Post Site Follow-up Study Questions

After quadrat data from all groups have been recorded on a master list, compare the data collected and complete the following:

1. Students should review the introductory information provided in this unit with regards to cordgrass, ribbed mussels and glasswort.

2. Are ribbed mussels found closer to glasswort plants or cordgrass?

3. Can glasswort and ribbed mussels be found close together?

4. Does the data support the background information that ribbed mussels and cordgrass have a cooperative relationship in terms of close proximity?

5. What other characteristics might need to be measured to determine if a cooperative relationship does exist between the above organisms?

6. Discuss common data, unique data and the variety in biodiversity.

Life on the Outer Banks – 10th Grade Edition
Salt Marsh Transect
On-Site Science Activity

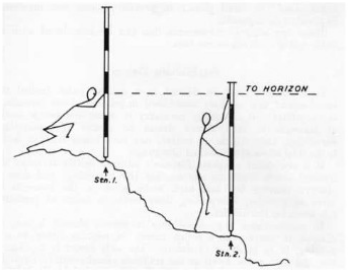
North Carolina Essential Standards Biology

Bio.2.1 Analyze the interdependence of living organisms within their environments.
Bio.2.1.3 Explain various ways organisms interact with each other (including predation, competition, parasitism, mutualism) and with their environments resulting in stability within the ecosystem.

Description:

A marsh transect and profile will allow students to see how the plant and animal life of the marsh changes in relation to the elevation above sea level and will use this information to better understand why plants and animals of the saltmarsh are distributed in the marsh as they are.

Each group will locate an area of the marsh to create a transect data base. Each group will use their pacing skills to establish their starting point for their marsh transect relative to other groups. Transects should be about 50 paces from each other. Each group will work together to use the transect rods, line level, and compass to measure the rise and fall of the land from the water's edge to the distance specified and identify the type of terrain, plants and animals discovered along the transect.



Materials (For each group of 4 students**)**

1 set of Transect Rods with an attached adjustable 3 meter string - stored at Cape Lookout
The set consists of a 1meter length stationary point rod made of PVC pipe with the string permanently attached to it and a 2 meter PVC lead transect rod with its midpoint marked as 0 with markings of each 100 cm's above the 0 marked as negative (–) values and each 100 cm's below the 0 marked as positive(+) values. Mm marks are marked on the lead transect lines and will be used in the calculations. The other end of the string has a loop that has been placed over the rod so it can be adjusted up or down until the line level shows level
1-Line Level
1-Compass

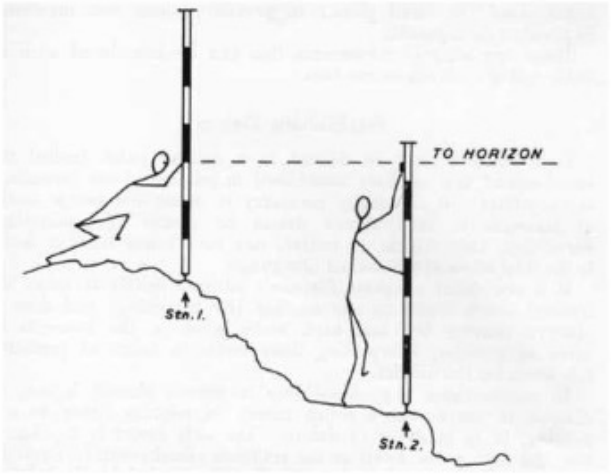
Directions for Each Group:

1. Starting at the water's edge, one group member will place the stationary point rod at the water's edge. Another student with the compass on a DUE SOUTH bearing should walk the lead transect rod along until the string is pulled tight. They will rest the end of the lead transect rod on the ground surface. With the line level near the midpoint of the 3 meter string, a third group member will move the string up or down on the lead transect rod until the bubble on the level is centered indicating that the line is level. That person will take a reading of the rise/fall in elevation (in MM's) and the fourth group member will record the information on the chart provided below. Values will be recorded for example as +1, +4. -2, -1etc. That first group member will now move the stationary point rod (shorter one) to the location of the lead transect rod and the second member will move the lead transect rod forward ---Keeping on the same DUE SOUTH course using the compass. The line will be leveled , measurement taken and recorded.
2. Each group will repeat the procedure until the group completes the 42 meters or they reach the hummock behind the marsh. A hummock is a term for the elevated tract of land rising above the general level of a marshy region.
3. At each measurement, groups should indicate the type of ground substrate, types of plants or animals present and general quantities of each.
4. With data collected , students will take it back to the classroom to create a profile of their region of the salt marsh.

Salt Marsh Transect

Handout # 1: Student Directions:

1. Starting at the water's edge, place the stationary point rod at the water's edge and note a DUE SOUTH bearing on the compass. Pull the string tight in the direction of the compass heading and place the end of the lead transect rod on to the ground surface. With the line level placed near the midpoint of the 3 meter string, move the string up or down on the lead transect rod until the bubble on the level is centered indicating that the line is level. Take a reading of the rise/fall in elevation (in MM's) and **record on the chart provided**.
   Values will be recorded for example as +1, +4. -2, -1 etc. Move the stationary point rod(shorter one) to the location of the lead transect rod and move the lead transect rod forward ---Keep on a DUE SOUTH course by using the compass--The string is 3 meter in length as indicated by the distances on the data chart on the back.
2. Repeat until you have completed the 42 meters or if you reach the hummock behind the marsh. A hummock is a term for the elevated tract of land rising above the general level of a marshy region.
3. At each measurement, indicate the type of ground substrate, types of plants or animals present and general quantities of each.
4. With data collected you will take it back to the classroom to create a profile of your region of the salt marsh.



…… Chart for Data You Collect is on the back of this sheet …….

Salt Marsh Transect Data Table - Circle below the relative position in the saltmarsh that your group's transect data represents:

100 paces left 50 paces left Class Gathering Area At the Beginning of Lab 50 paces right 100 paces right

Location	Rise (- value) Or Fall (+value) in mm's	Convert +/- Values into the total cumulative mm's	Convert mm's into cm's	Observations (Soil description, plants and animals present and numbers of each)
Water's Edge	**0**	**0**	**0**	
3 M				
6 M				
9 M				
12 M				
15 M				
18 M				
21 M				
24 M				
27 M				
30 M				
33 M				
36 M				
39 M				
42 M				

As you complete the transect be sure to convert your simple + or - value into total mm change by adding or subtracting the value from previous value. These values will indicate total elevation change from the water's edge in mm's. Next convert mm's to cm's for ease in graphing later.

Life on the Outer Banks – 10th Grade Edition
Salt Marsh Profile
Post Site Science Activity

North Carolina Essential Standards Biology

Bio.2.1 Analyze the interdependence of living organisms within their environments.
Bio.2.1.3 Explain various ways organisms interact with each other (including predation, competition, parasitism, mutualism) and with their environments resulting in stability within the ecosystem.

Description:
A marsh profile created from data collected from the marsh transect will allow students to see how the marsh changes in height above sea level and will be able to use this information to better understand why plants and animals of the salt marsh disperse as they do.

Materials:
Transect Data
Large sheet of graph paper
Color Pencils (optional)
Ruler

Directions:

1. Give each student a piece of graph paper, pencil, and a ruler
2. Have students set up their graph so that the horizontal distance intervals covered in the marsh beginning with 0(at water's edge) are on the x axis and equadistant elevations above sea level beginning with 0 (sea level) are displayed on the vertical y axis. Use as much of graph paper as possible to keep distortions to a minimum.
3. Use the Transect Data Sheet to plot the converted elevations on the graph for each horizontal distance.
4. Use color pencils to denote sand, mud, grass areas, shrubs etc. as your sampling progressed from the water's edge. Draw examples of animals you may have encountered.
5. Once graphs are complete, review the profiles. Note similarities and differences between the profiles from different sampling areas. What might that indicate about the marsh? How did the elevation changes compare when looking across the entire sampled area?
6. **Alternate Option for Graphing:** Instead of a paper graph profile completed by hand, students may wish to opt for creating a computer generated model using EXCEL. This could then be printed to share or placed on a class or school website.
   -Create a profile spreadsheet: A column- x axis values: 3,6,9,12 M… etc.
   B column – y axis values: elevations in cm's
   -Click at the top of the excel program and choose Insert and click on charts. Choose scatter and it will create a plotted graph of your data. This can then be copied to a separate sheet and enlarged to be turned in to the teacher.

Life on the Outer Banks – 10th Grade Edition
Salt Marsh Flora and Fauna – Up Close and Personal with Mollusks
On Site or Post Site Science Activity

North Carolina Essential Standards Biology

Bio.2.1 Analyze the interdependence of living organisms within their environments.
Bio.2.1.3 Explain various ways organisms interact with each other (including predation, competition, parasitism, mutualism) and with their environments resulting in stability within the ecosystem

NOAA Photo Library

Description:
This activity is an opportunity for students to closely examine the characteristics and behaviors of a common marsh creature found in North Carolina's Cape Lookout National Seashore marshes- the periwinkle snail.

THE PERIWINKLE SNAIL, *Littoraria irrorata*, inhabits salt marshes from New York to Texas. When the tide rises, they ascend the grass stalks until well above water level. Periwinkles consume diatoms and filamentous algae, and follow each other's mucous trails, up and down the stalks. **Have your students ever hummed to a snail? – If not, this lab will give them that chance!!**

Supplies:
Plastic 20 oz. drink cup or small plastic pail
Small plastic metric ruler
Stopwatch or other timing device
Clip Board
Lab sheet
Periwinkle Snail

Students will work with a Partner *in situ* (on site)
1)Students will choose a periwinkle snail from a nearby spartina plant.
2) Students will move to an area of the marsh where they can sit and observe their mollusk. They will record information in a table like the one below. Students need to be as exacting as they can with their measurements. They should prepare to write down colors, special markings/patterns, scars, etc…

Shell Length (straight cm)	Shell Length (curved cm)	Shell Width (cm)	Color(s)	Specific Markings

If after basic information has been gathered and it has not emerged from its shell: students should start to HUM! **Holding the periwinkle in their hand and directing their humming to its shell, the vibrations coax it out! Snails react to vibrations by relaxing their muscles and in turn the snail emerges. Students can now gather information about its softer body parts!**

Soft Body Measurement as you can (cm/guesstimation)	Soft Body Markings	Behaviors

3) Depending on how long the above measuring/ observing has taken- students should return their snail to the water to moisten his body!!! They should not release the snail yet- since there is more to do! Continue with the lab!

4) Students will expand their study a little farther by timing their movement over a distance of @ 5 cm.

On the sandy mud flat- students will create a circle about 10 cm diameter by pressing the open end of their cup or pail into the substrate.

Placing their snail at the center of that circle, they will time how long it takes to cross the perimeter line you made.

TIME: _____

What did you notice about its movement? Straight line? Meander? List below:

Students will repeat this procedure 2 more times and average.

TIME #2 _____ TIME #3 _____ **Average time needed**: _____

Record average times for 3 other groups working near you

Group A- Average time:_____
Group B- Average time:_____
Group C- Average time:_____

Extending the Concept: Students tested the time it took for their snail to move about on the substrate. Students should observe what happens if they introduce food to the edge of the circle or place a predator like a blue crab in the circle with the snail?

Students have one last chance to memorize their snail! Students should take notice of all the mannerisms/behaviors they can! They may NOT write on it/ tag it with marks/glue etc….. Students will return it to the teacher's bucket! The teacher will now gently place them all in yet another "container". Students will see if they can pick theirs out!

Life on the Outer Banks – 10th Grade Edition
Salt Marsh Flora and Fauna – Up Close and Personal with Mollusks

Handout # 1: Student Lab Sheet
In situ Lab (on site)

Supplies:
Plastic 20 oz. drink cup or small plastic pail
Small plastic metric ruler
Stopwatch or other timing device
Clip Board
Lab sheet
Periwinkle Snail

Directions: Work with a Partner:

1) Select a periwinkle snail from a nearby spartina plant.
2) Move to an area of the marsh where you can sit and observe your mollusk.
Record information in the table below. -Be as exacting as you can with your measurements.
-Write down colors, special markings/patterns, scars

Shell Length (straight cm)	Shell Length (curved cm)	Shell Width (cm)	Color(s)	Specific Markings

If after basic information has been gathered and it has not emerged from its shell: start to HUM! **If you hold a periwinkle in your hand and direct your humming to its shell, the vibrations coax it out! Snails react to vibrations by relaxing their muscles and in turn the snail emerges. Now you can gather information about its softer body parts!**

Soft Body Measurement as you can (cm/guesstimation)	Soft Body Markings	Behaviors

3) Depending on how long the above measuring/ observing has taken- return your snail to the water to moisten his body!!! Don't let him go yet- you have more to do! Continue with the lab!

4) Now expand your study a little farther by timing their movement over a distance of @ 5 cm. On the sandy mud flat- create a circle about 10 cm diameter by pressing the open end of your cup or pail into the substrate.

Place your snail at the center of that circle and time how long it takes to cross the perimeter line you made.

TIME: _____

What did you notice about its movement? Straight line? Meander? List below:

Repeat 2 more times and average.

TIME #2 _____ TIME #3 _____ **Average time needed**: _____

Record average times for 3 other groups working near you

Group A- Average time:_____
Group B- Average time:_____
Group C- Average time:_____

Extending the Concept: You have tested the time it takes for your snail to move about on the substrate. What might happen if you introduce food to the edge of the circle or place a predator like a blue crab in the circle with the snail?

One last chance to memorize your snail! Look at it closely- notice all the mannerisms/behaviors you can! You may NOT write on it/ tag it with marks/glue etc…..
Return it to the teacher's bucket!

The teacher will now gently place them all in yet another "container".
See if you can pick yours out!

Salt Marsh Flora and Fauna – Up Close and Personal with Mollusks

Handout #2: Student Lab Sheet (IF Doing this lab as a Post Visit Activity)

1) From the container at the front of the room select a periwinkle snail.

2) Return to your desk and observe your mollusk. Record information in the table below.

-Be as exacting as you can in your measurements .

-Write down colors, special markings/patterns, scars

Shell Length (straight cm)	Shell Length (curved cm)	Shell Width (cm)	Color(s)	Specific Markings

If after basic information has been gathered and it has not emerged from his shell: start to HUM! **If you hold a periwinkle in your hand and direct your humming to its shell, the vibrations coax it out!**

Snails react to vibrations by relaxing their muscles and in turn the snail emerges. Now you can gather information about its softer body parts!

Soft Body Measurement As you can (cm/guestimation)	Soft Body Markings	Behaviors

3) Depending on how long the above measuring/ observing has taken- return your snail to the front to dip in water in the original container –DO NOT RUN UNDER FAUCET!!! Take it back to your desk!

4) Now expand your study a little farther by timing their movement over a distance of @ 5 cm.

On a piece of color paper- draw a circle with a compass having a 5 cm radius.

Place your snail at the center and time how long it takes to cross the perimeter line you drew.

TIME: _____

What did you notice about its movement? Straight line? Meander? List below:

Repeat 2 more times and average.

TIME #2 _____TIME #3 _____ **Average time needed**: _____

Record average times for 3 other groups working near you

Group A- Average time:_____

Group B- Average time:_____

Group C- Average time:_____

One last chance to memorize your snail! Look at it closely- notice all the mannerisms/behaviors you can.

You may NOT write on it/ tag it with marks/glue etc….. Return it to the container at the front! The teacher will now place them all in another "container". See if you can pick yours out!

Salt Marsh Flora and Fauna- Up Close and Personal with Mollusks

Handout # 3: Student Lab Sheet: Field Study Questions

1. As the snail made its way out of the center of the circle, what movements did it exhibit? Did it stay in a straight line, meander about, stop for extended time, turn back?

2. Do you think if you had placed a blade of cordgrass down it would have followed better? Why or why not?

3. How does your snail's average time compare to that of snails in the other groups?

4. List 2 reasons why they are or are not similar:

5. What was your criteria for determining which snail was yours when they were all mixed together?

6. What is the ecological significance of the snails being so similar to one another?

Life on the Outer Banks – 10th Grade Edition
Salt Marsh – A Rachel Carson Perspective
Post Site Science/English Activity

North Carolina Essential Standards Biology

Bio.2.1 Analyze the interdependence of living organisms within their environments.

English Language Arts Standards Science & Technical Subjects

CCSS.ELA-Literacy.RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text .

Description:
One cannot visit a salt marsh or work with information gleaned from such an experience, without being reminded of the literary work of Rachel Carson. Rachel Carson's connection to eastern North Carolina is extensive. She spent recovery time, after breast cancer surgery, along the coast of North Carolina. She was inspired to write *The Edge of the Sea* in 1955 sharing observations made in part along the shores here. In 1985, an estuary in Beaufort was named in honor of her and to commemorate her pioneering pursuit of environmental awareness and protection.
While chemical companies were opposed to the content within *Silent Spring*, when it was published in 1962, it was instrumental in prompting the reversal of a national pesticide policy. It resulted in a nationwide ban of DDT and other dangerous pesticides. Her writings also inspired the beginnings of an environmental movement that eventually led to the creation of the U.S. Environmental Protection Agency.

Materials:
Handout 1: Excerpt from *Silent Spring*: Chapter 1 "*A Fable for Tomorrow"*
Handout 2: DDT Information Sheet
Worksheet Rachel Carson- Environmental Crusader

Directions:
1. Students will use the two handouts provided: *A Fable for Tomorrow* and *DDT* to complete Part 1 of the Rachel Carson- Environmental Crusader worksheet.
2. Students will use their knowledge gleaned from their reading and personal research to find a Rachel Carson "wannabe" from history or literature.
3. Remind students of the following:
   Rachel Carson risked her professional reputation to communicate her findings in *Silent Spring* to the public. She was motivated to bring light to a topic she believed was important, no matter the outcome.

Salt Marsh – A Rachel Carson Perspective

Handout 1: Excerpt from *Silent Spring*

Rachel Carson. from *Silent Spring* (Houghton Mifflin, 1962).

A FABLE FOR TOMORROW

There was once a town in the heart of America where all life seemed to live in harmony with its surroundings. The town lay in the midst of a checkerboard of prosperous farms, with fields of grain and hillsides of orchards where, in spring, white clouds of bloom drifted above the green fields. In autumn, oak and maple and birch set up a blaze of color that flamed and flickered across a backdrop of pines. Then foxes barked in the hills and deer silently crossed the fields, half hidden in the mists of the fall mornings.

Along the roads, laurel, viburnum and alder, great ferns and wildflowers delighted the traveler's eye through much of the year. Even in winter the road- sides were places of beauty, where countless birds came to feed on the berries and on the seed heads of the dried weeds rising above the snow. The country- side was, in fact, famous for the abundance and variety of its bird life, and when the flood of migrants was pouring through in spring and fall people traveled from great distances to observe them. Others came to fish the streams, which flowed clear and cold out of the hills and contained shady pools where trout lay. So it had been from the days many years ago when the first settlers raised their houses, sank their wells, and built their barns.

Then a strange blight crept over the area and everything began to change. Some evil spell had settled on the community: mysterious maladies swept the flocks of chickens; the cattle and sheep sickened and died. Everywhere was a shadow of death. The farmers spoke of much illness among their families. In the town the doctors had become more and more puzzled by new kinds of sickness appearing among their patients. There had been several sudden and unexplained deaths, not only among adults but even among children, who would be stricken suddenly while at play and die within a few hours.

There was a strange stillness. The birds, for example where had they gone? Many people spoke of them, puzzled and disturbed. The feeding stations in the backyards were deserted. The few birds seen anywhere were moribund; they trembled violently and could not fly. It was a spring without voices. On the mornings that had once throbbed with the dawn chorus of robins, catbirds, doves, jays, wrens, and scores of other bird voices there was now no sound; only silence lay over the fields and woods and marsh.

On the farms the hens brooded, but no chicks hatched. The farmers complained that they were unable to raise any pigs the litters were small and the young survived only a few days. The apple trees were coming into bloom but no bees droned among the blossoms, so there was no pollination and there would be no fruit.

The roadsides, once so attractive, were now lined with browned and 249 withered vegetation as though swept by fire. These, too, were silent, deserted by all living things. Even the streams were now lifeless. Anglers no longer visited them, for all the fish had died.

In the gutters under the eaves and between the shingles of the roofs, a white granular powder still showed a few patches; some weeks before it had fallen like snow upon the roofs and the lawns, the fields and streams.

No witchcraft, no enemy action had silenced the rebirth of new life in this stricken world. The people had done it themselves.

This town does not actually exist, but it might easily have a thousand counterparts in America or elsewhere in the world. I know of no community that has experienced all the misfortunes I describe. Yet every one of these disasters has actually happened somewhere, and many real communities have already suffered a substantial number of them. A grim specter has crept upon us almost unnoticed, and this imagined tragedy may easily become a stark reality we all shall know. ...

THE OBLIGATION TO ENDURE

The history of life on earth has been a history of interaction between living things and their surroundings. To a large extent, the physical form and the habits of the earth's vegetation and its animal life have been molded by the environment. Considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight. Only within the moment of time represented by the present century has one species man acquired significant power to alter the nature of his world.

During the past quarter century this power has not only increased to one of disturbing magnitude but it has changed in character. The most alarming of all man's assaults upon the environment is the contamination of air, earth, rivers, and sea with dangerous and even lethal materials. This pollution is for the most part irrecoverable; the chain of evil it initiates not only in the world that must support life but in living tissues is for the most part irreversible. In this now universal contamination of the environment, chemicals are the sinister and little-recognized partners of radiation in changing the very nature of the world, the very nature of its life. Strontium 90, released through nuclear explosions into the air, comes to earth in rain or drifts down as fallout, lodges in soil, enters into the grass or corn or wheat grown there, and in time takes up its abode in the bones of a human being, there to remain until his death. Similarly, chemicals sprayed on croplands or forests or gardens lie long in soil, entering into living organisms, passing from one to another in a chain of poisoning and death. Or they pass mysteriously by underground streams until they emerge and, through the alchemy of air and sunlight, combine into new forms that kill vegetation, sicken cattle, and work unknown harm on those who drink from once pure wells. As Albert Schweitzer has said, "Man can hardly even recognize the devils of his own creation."

It took hundreds of millions of years to produce the life that now inhabits the earth eons of time in which that developing and evolving and diversifying life reached a state of adjustment and balance with its surroundings. The environment, rigorously shaping and directing the life it supported, contained elements that were hostile as well as supporting. Certain rocks gave out dangerous radiation; even within the light of the sun, from which all life draws its energy, there were short-wave radiations with power to injure. Given time, not in years but in millennia, life adjusts, and a balance has been reached. For time is the essential ingredient; but in the modern world there is no time.

The rapidity of change and the speed with which new situations are created follow the impetuous and heedless pace of man rather than the deliberate pace of nature. Radiation is no longer merely the background radiation of rocks, the bombardment of cosmic rays, the ultraviolet of the sun that have existed before there was any life on earth; radiation is now the unnatural creation of man's tampering with the atom. The chemicals to which life is asked to make its adjustment are no longer merely the calcium and silica and copper and all the rest of the minerals washed out of the rocks and carried in rivers to the sea; they are the synthetic creations of man's inventive mind, brewed in his laboratories, and having no counterparts in nature.

To adjust to these chemicals would require time on the scale that is nature's; it would require not merely the years of a man's life but the life of generations. And even this, were it by some miracle possible, would be futile, for the new chemicals come from our laboratories in an endless stream; almost five hundred annually find their way into actual use in the United States alone. The figure is staggering and its implications are not easily grasped500 new chemicals to which the bodies of men and animals are required somehow to adapt each year, chemicals totally outside the limits of biologic experience.

Among them are many that are used in man's war against nature. Since the mid-1940's over 200 basic chemicals have been created for use in killing insects, weeds, rodents, and other organisms described in the modem vernacular as "pests"; and they are sold under several thousand different brand names.

These sprays, dusts, and aerosols are now applied almost universally to farms, gardens, forests, and homes nonselective chemicals that have the power to kill every insect, the "good" and the "bad," to still the song of birds and the leaping of fish in the streams, to coat the leaves with a deadly film, and to linger on in soil all this though the intended target may be only a few weeds or insects. Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life? They should not be called "insecticides," but "biocides."

The whole process of spraying seems caught up in an endless spiral. Since DDT was released for civilian use, a process of escalation has been going on in which ever more toxic materials must be found. This has happened because insects, in a triumphant vindication of Darwin's principle of the survival of the fittest, have evolved super races immune to the particular insecticide used, hence a deadlier one has always to be developed and then a deadlier one than that. It has

happened also because, for reasons to be described later, destructive insects often undergo a "flareback," or resurgence, after spraying, in numbers greater than before. Thus the chemical war is never won, and all life is caught in its violent crossfire.

Along with the possibility of the extinction of mankind by nuclear war, the central problem of our age has therefore become the contamination of man's total environment with such substances of incredible potential for harm substances that accumulate in the tissues of plants and animals and even penetrate the germ cells to shatter or alter the very material of heredity upon which the shape of the future depends. . . .

THE OTHER ROAD

We stand now where two roads diverge. But unlike the roads in Robert Frost's familiar poem, they are not equally fair. The road we have long been traveling is deceptively easy, a smooth superhighway on which we progress with great speed, but at its end lies disaster. The other fork of the road the one "less traveled by" offers our last, our only chance to reach a destination that assures the preservation of our earth.

The choice, after all, is ours to make. If, having endured much, we have at last asserted our "right to know," and if, knowing, we have concluded that we are being asked to take senseless and frightening risks, then we should no longer accept the counsel of those who tell us that we must fill our world with poisonous chemicals; we should look about and see what other course is open to us.

A truly extraordinary variety of alternatives to the chemical control of insects is available. Some are already in use and have achieved brilliant success. Others are in the stage of laboratory testing. Still others are little more than ideas in the minds of imaginative scientists, waiting for the opportunity to put them to the test. All have this in common: they are biological solutions, based on understanding of the living organisms they seek to control, and of the whole fabric of life to which these organisms belong. Specialists representing various areas of the vast field of biology are contributing entomologists, pathologists, geneticists, physiologists, biochemists, ecologists all pouring their knowledge and their creative inspirations into the formation of a new science of biotic controls. . .

Through all these new, imaginative, and creative approaches to the problem of sharing our earth with other creatures there runs a constant theme, the awareness that we are dealing with life with living populations and all their pressures and counter pressures, their surges and recessions. Only by taking account of such life forces and by cautiously seeking to guide them into channels favorable to ourselves can we hope to achieve a reasonable accommodation between the insect hordes and ourselves.

The current vogue for poisons has failed utterly to take into account these most fundamental considerations. As crude a weapon as the cave man's club, the chemical barrage has been hurled against the fabric of life a fabric on the one hand delicate and destructible, on the other

miraculously tough and resilient, and capable of striking back in unexpected ways. These extraordinary capacities of life have been ignored by the practitioners of chemical control who have brought to their task no "high-minded orientation," no humility before the vast forces with which they tamper.

The "control of nature" is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy, when it was supposed that nature exists for the convenience of man. The concepts and practices of applied entomology for the most part date from that Stone Age of science. It is our alarming misfortune that so primitive a science has armed itself with the most modem and terrible weapons, and that in turning them against the insects it has also turned them against the earth.

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Salt Marsh- A Rachel Carson Perspective

Handout 2: DDT Information

What is DDT?

DDT (dichlorodiphenyltrichloride) is a synthetic pesticide. [29] Synthetics are artificially-crafted, meaning that they are produced by humans and not found in nature. A pesticide is a chemical used to kill pests, such as insects. At first, DDT was widely used to eliminate mosquitoes that carry the harmful disease, malaria, but later it was used on farms and in industrial processes to control agricultural pests, such as various potato beetles, coddling moth, corn earworm, cotton bollworm, and tobacco budworms.[30] Its purpose was to increase the amount of food produced on farms by killing the pests that were destroying crops. Yet, as Rachel Carson demonstrates in her book, *Silent Spring*, there were dangerous and adverse effects to DDT.

DDT is insoluble in water. This means it cannot be dissolved in water, so it is difficult to remove from the environment or the tissues of living organisms. One group of animals most vulnerable to DDT is aquatic invertebrates. These include small insects and other creatures without backbones that live in water, such as clams and worms, which constitute a substantial portion of the food chain. While DDT is insoluble in water, it is readily dissolvable in fats, including the fat tissues found in animals (and people). Because of DDT's fat solubility, fats in animals can become storehouses for DDT accumulation. Therefore, DDT cannot be removed from water but is soaked up by fat. Its solubility and insolubility make DDT a persistent pollutant: a toxin that just won't go away!

"One of the reasons why we worry about DDT is because it doesn't break down in the environment or in organisms." - University of San Diego, Creators of Cruising Chemistry[31]
How much DDT is bad for you? The answer to this depends on the amount of DDT that you are exposed to, how much DDT you carry in your body, and your weight. Nevertheless, even a small amount as low as six to ten milligrams of DDT per kilogram, can cause nausea, diarrhea, irritation, and excitability. One of the more severe symptoms is losing control of your muscles, either through erratic movements or paralysis. [32] DDT also affects other animals. For example, it can disturb the reproductive processes of certain birds, such as the thinning of eggshells, or lead to imbalance of ions in cells that affects the nervous systems in some fish.[33]

DDT started being more widely used on farms for pest control in the 1940s. From 1947 to 1960, the use of pesticides went from 1.24 to 6.37 million pounds, growing fivefold over a 13 year span.[34] The dangerous effects of pesticides were not well known until Rachel Carson's book *Silent Spring,* in which "A Fable for Tomorrow" illustrated DDT's adverse effects. While DDT helped farmers to reduce crop damage and loss, Rachel Carson is known for conducting research and bringing attention to the damage it causes to other living systems. The book shocked and concerned so many Americans that then U.S. President John F. Kennedy ordered a scientific investigation on DDT. Later, the U.S. Environmental Protection Agency (EPA) decided that a process to remove its use in agriculture should begin immediately and a ban took place in the U.S. in 1972. Consequently, a worldwide ban was instituted in 2004 under the Stockholm Convention. [35] The Convention, however, was limited and still allowed for developing countries

to use DDT to counteract malaria; a full ban is now being sought, as well as the broader implementation of safer alternatives.[36]

"Our aim should be to guide natural processes as cautiously as possible in the desired direction rather than to use brute force. . . Life is a miracle beyond our comprehension, and we should reverence it even when we have to struggle against it . . . Humbleness is in order; there is no excuse for scientific conceit here." – Rachel Carson in *Silent Spring*[37]

Footnotes

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Handout #3 : Rachel Carson- Environmental Crusader

Name: _____

Date: _____

Part 1

Directions: After reading the information about DDT, answer the following questions. You will be relating what you read in Rachel Carson's "A Fable for Tomorrow" to what you have just learned about DDT.

1. What is Carson warning us about?

2. Why do you think Carson titles it "A Fable for Tomorrow"? Think about the choice of words in the title.

4. A question is asked in the fable: "What has already silenced the voices of spring in countless towns in America?" What is the answer?

Critical Thinking Questions:

1. After reading the short information on DDT, what side effect do you think Carson is describing when she says "They [the birds] trembled violently?"

2. "On the farms the hens brooded, but no chicks hatched" refers to what category of DDT's effects?

3.(Open-ended Question) Rachel Carson states that "humbleness" is required when we begin to work with nature. What do you think she means? How can we have humbleness toward nature?

Part 2: Rachel Carson "Wannabe" from Literature and History

1. List what qualities Rachel Carson must have had in order to write this book.

2. Think of your favorite literary, movie or television character that reminds you of Rachel Carson and why?

3. What historical figures do you recall that remind you of Rachel Carson and why?

4. Who have you personally known that reminds you of Rachel Carson. What is it about them that lets you make that connection?

5. Which of Rachel Carson's attributes would you like to exhibit in your life?

6. How would that change your present outlook? Your future plans?

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