Sapelo Island
Georgia's Coastal Treasure

Sponsored by:
Georgia Department of Natural Resources
Sapelo Island National Estuarine Research Reserve
and
The National Oceanic and Atmospheric Administration

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Acknowledgements

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To all those who I have not mentioned who gave their support, encouragement and advice.

Dedication

I would like to dedicate this guide to all the students and teachers of Georgia with the following statement made by The National Science Foundation (1978).

What science education will be for any one child for any one year is most dependent on what that child’s teacher believes, knows and does—and doesn’t believe, doesn’t know, and doesn’t do. For essentially all of the science learned in the school, the teacher is the enabler, the inspiration, and the constraint.

It is my hope that this guide will enable teachers all over the state of Georgia and beyond to enable and inspire their students by providing a better understanding of the importance of preserving the wonderful but fragile habitats of our coast.
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SAPELO HISTORY

The history of human culture on Sapelo Island is a brief wink compared with the island's geological history, yet human occupation and use of the island have contributed significantly to its present physical condition. First inhabited by Native Americans around 4,500 years ago, Sapelo has been hunted, farmed and built upon ever since, so certain of its physical features and landmark structures are the direct result of human activity.

Sapelo has a colorful past, characterized by succeeding phases of occupation by various cultures. Spanish missionaries established small settlements and missions for the natives there beginning in the mid-1500s but were driven out within 100 years. British colonials and French nobles fleeing their country's revolution followed. Beginning in 1802 and lasting until 1969 when the state of Georgia began its purchase of the island, Sapelo was owned, cultivated, developed and cared for by a series of three American magnates. From the first Indian occupants, through its period of private ownership to its current status as a wildlife preserve and research facility, Sapelo has always been treated with respect by preservation-minded individuals and thus, fortunately, exists in near pristine condition today.

NATIVE AMERICAN ORIGINS

Research and archaeology presented by state archaeologist Dr. Lewis Larson and colleagues at West Georgia College in their Sapelo Papers offer an informative picture of Indian culture on Sapelo. Shell Ring, Bourbon Field and Kenan Field are three major excavation sites that have provided information on the native culture. Sapelo was inhabited, as were several in the chain of Georgia's barrier islands, by Creek tribes who called themselves Guale, after the name of one of their chieftains. These tribes were highly civilized and politically organized, living in permanent settlements of cabins made from poles daubed with earth, leaves or moss.

Shell Ring, located on the northwestern side of the island between Chocolate and High Point, is composed of shells from oysters, clams and whelks and is most likely an accumulation of refuse from a settlement situated in a circle around the ring. These shellfish were a large component of the Indians' diet. Indians were also known to cultivate and eat corn, beans, melons and fruit and to hunt and eat the animals indigenous to the island. They also raised and smoked tobacco. Bone pins and pottery found at Shell Ring have been dated at 3,700 years B.C., give or take 250 years. Now overgrown with live oak, palmetto, myrtle and grapevines, Shell Ring was thought to be the ruins of a Spanish Fort by older residents of Sapelo and is marked as such on some old maps. Research has since proven that the site was indeed either an Indian fortification or ceremonial enclosure. In 1872 William McKinley measured the ring at a diameter of 300 feet and a height of five to seven feet. In 1895 scientist Clarence Moore confirmed these measurements, adding that the ring is 50 feet thicker at its base. In 1950 Larson dug an excavation trench across the ring that is still visible today.

Bourbon Field, located at the north end, was a village site that has since been plowed extensively for agriculture. Occupied by Indians from around 1,000 AD through the 1680s, the site has
produced 119 shell middens and a small earthen mound. Kenan Field was a 158-acre village occupied between about 1,000 AD. and 1,600 AD. It contains a large burial mound, a smaller mound and a long earth embankment running east to west about 500 feet south of the large mound. There is evidence of the existence of two large buildings separated by a plaza, which were used for political and ceremonial events. Archaeologists theorize that village culture here was very structured and formal.

**SPANISH MISSION INFLUENCE**

Spanish missionaries first arrived at Sapelo in 1568. Jesuit priests reportedly established a small mission on the island at that time, but stayed only until 1570 when the Indians rebelled and murdered several of them. Franciscans arrived to try again in 1573 and established the convent of San Jose de Zapala. The name Zapala was later anglicized to Sapeloe, thus the name of the island. The mission of San Jose was probably abandoned at the same time as Santa Catalina de Guale on St. Catherines Island in 1686 due to unrest among colonials and natives in the area.

**BRITISH COLONIZATION**

When the British colony of Georgia was established in 1733, the Creeks granted all Georgia coastal lands to the English except the islands of Ossabaw, St. Catherines and Sapelo, which they reserved for themselves as hunting grounds. In 1747 the Creek chief Malatche gave the latter three islands to Mary Musgrove Bosomworth, the half-Creek, half-British niece of the Creek emperor and interpreter and diplomat in the employ of General Oglethorpe. Colonial authorities rejected Mary's claim to the islands and a 10-year dispute ensued with Mary eventually owning St. Catherines and taking money from the sale of Ossabaw and Sapelo to the English as compensation for her services to Oglethorpe.

In 1760 British land speculator Grey Elliot purchased Sapelo at auction from the British Crown for 725 pounds. Elliot then sold the island in 1762 to Patrick Mackay, a Scotsman and Indian trader, who first conducted large-scale farming there. In 1784 John McQueen of South Carolina purchased Sapelo from the Mackay estate and continued agricultural operations there, but not for long, as he lived beyond his means and was forced to sell Sapelo, Little Sapelo, Blackbeard and Cabretta Islands for a total of 10,000 pounds in 1789.

**FRENCH OCCUPATION**

The buyers were a group of five French noblemen fleeing the revolution in France. Of this group, one departed shortly afterward to Jekyll Island, and two died in 1794, leaving only two: Jean de Boisfeuillet and the Grand Closmesle. De Boisfeuillet lived at his Sapelo home, Bourbon, for many years until the death of his wife when he moved to the mainland to be near his daughter. He died there in 1800. In the late 1790s the Grand Closmesle's share of the island was purchased by the Marquis de Montalet, who had left Santa Domingo in the wake of the slave rebellion there. After the death in 1805 of his wife, who happened to be de Boisfeuillet's daughter Angélique, Montalet moved to Sapelo to live at High Point where he spent his time farming and enjoying gracious living.
THOMAS SPALDING

Montalet had a couple of American neighbors on the island during this time who were his close friends until he died in 1814. In 1801, Richard Leake (father-in-law of Thomas Spalding) and Edward Swarbreck had purchased a tract of the island called Chocolate, south of High Point facing Mud River and looking toward Creighton Island. Leake died in 1802, leaving his property to Thomas Spalding, who purchased 4,000 acres on Sapelo's south end in the same year.

Chocolate had been owned by Villehuchet and Grand Clos Mesle as early as 1790. It was bought in 1797 by Lewis Harrington, who then sold it to Leake and Swarbreck. Swarbreck gradually developed his Chocolate land into a profitable farming operation, constructing a group of tabby buildings between 1815 and 1819 whose ruins still stand. He continued to be a good neighbor to Montalet and Spalding until 1827 when he sold his Chocolate holdings to Dr. Charles W. Rogers, who continued operating the plantation, making improvements and acquiring more property so that by the 1830s he owned most of the north end of the island. Rogers built a two-story frame home with a tabby basement at Chocolate in the 1830s. Extensive ruins of the manor house, barns, slave houses and several outbuildings remain at Chocolate.

In 1843 Thomas Spalding bought the 7,000 acres of Sapelo's north end and gave the tract to his son Randolph as a wedding gift. Randolph and family lived at Chocolate until 1853 when the Rogers house burned. This tract included the aforementioned Bourbon Field. After the Civil War, the tract was sold by Mary Bass Spalding to John A. Griswold, who used part of the land to grow sea island cotton during the Reconstruction period. The tract was sold again to James Cassin in 1873.

Thomas Spalding (in 1835) gave 1,500 acres of the north end, including Kenan Field, to his daughter Catharine, who married Michael J. Kenan of Milledgeville, from whom Kenan Field gets its name. They built a home there in the 1850s and called it "Duplin." They grew sea island cotton and corn until 1861 when they left because of the war. In 1872 their son, Dr. Spalding Kenan, bought his family's interest in the property and lived there until 1880. The site was sold to Howard Coffin on June 6, 1912, whereupon it was leased for turpentine rights, oystering rights and raising cattle.

A group of tabby ruins from the Kenan plantation remain today at a site called Hanging Bull, so named because of a bull that was left hanging in a tree after the hurricane of 1824. The ruins consist of barns and storehouses, a slave school built by Thomas Spalding and a church dating to the 1870s. Slave quarters for the Kenan plantation were located just east of Hanging Bull.

Thomas Spalding was a politician, banker and agriculturist who led Sapelo through the only significant money-making period in its history. He sold live oak to the shipbuilding industry, planted long-staple cotton, sugarcane and corn and conducted extremely productive experiments in crop diversification and rotation. He also drained the interior of the island by a series of ditches. Spalding pioneered the sugar industry in Georgia and the tabby walls of his sugar mill on Sapelo still stand.
In 1807-1810 Spalding designed and constructed a plantation mansion, South End House, at the southern end of the island on the Atlantic. He built the house low to the ground with thick tabby walls to withstand storms. This was fortuitous, as the house endured the vicious hurricane of 1824 which sent six-foot waves over the front yard.

In 1808 Spalding sold five acres of the island’s south end to the federal government for $1, for use as a lighthouse site. In 1820 the federal lighthouse service contracted Winslow Lewis of Boston to construct a 90-foot brick tower and an adjoining house for the lighthouse keeper.

In 1809 Thomas Spalding built a cane grinding mill and sugar boiling house at a site called Long Tabby. In 1871 Thomas II and Sarah Spalding rebuilt Long Tabby sugar works and lived there until 1877 during construction of the house at south end. In 1877 William Nightingale, a close Spalding friend, bought the property and lived there for a couple of years before renting it to William Wyly. The property was later purchased by Kate Treanor, who was Wyly’s sister and Mrs. Thomas Spalding II’s niece. During reconstruction of the south end house from 1922-1925, Howard Coffin lived at Long Tabby, and in 1948 R.J. Reynolds remodeled it for use as a Boys Camp. Sold to the Department of Natural Resources by Reynolds’ widow Anne Marie in 1969, Long Tabby now houses the offices of the DNR and the SINERR.

Thomas Spalding died in 1851 and his heirs continued plantation operations and lived on Sapelo at least part-time for 10 more years until the beginning of the Civil War. Confederate troops were stationed on the island for coastal defense but evacuated in 1862 when federal forces gained control of the Georgia sea islands. The Confederates removed the lens apparatus from the lighthouse that had been built in 1820 to prevent its use by the Union. After this evacuation the plantation and South End House fell into ruin as the island was left to Spalding’s former slaves and Union naval forces.

In 1865 Union General William T. Sherman decreed that freed slaves be given land to live on and farm on the sea islands and after the war Spalding’s freed slaves established their own communities on Sapelo. Over the years the Spalding heirs sold parts of their property on the island to various buyers, including a hunting club from Macon, which acquired some of the south end, including the ruined house. In 1907 the hunting club rebuilt the center section of South End House to serve as a hunting lodge.

As for the lighthouse, it was reactivated in 1868 and painted with horizontal red and white bands. A skeleton beacon light was placed near the tower, to be replaced by an iron beacon in 1877. Eventually the old brick lighthouse itself was abandoned. In 1905 a new 100-foot steel tower was built and it functioned until 1933 when it was dismantled. In 1992 the tract of land with the now 175 year old lighthouse was bought by the state. Currently, the Department of Natural Resources is raising money for its restoration.

HOWARD COFFIN

The second millionaire to own Sapelo was Howard Coffin, one of the founders of the Hudson Motor Company. He purchased the entire island except for the African American communities at
Shell Hammock, Hog Hammock and Raccoon Bluff from its various owners in 1912 and immediately set about revitalizing it.

Coffin employed Sapelo's African American population in shrimping and oyster canning. He planted long-staple cotton and food crops, built roads, raised cattle, began a sawmilling operation and sank artesian wells. The Coffin family added an outdoor swimming pool and some additional columns to South End House and began living there part-time. In 1922-1925 Coffin restored the home completely, adding a second story, indoor swimming pool and an adjacent guest house and made it his full-time residence.

Coffin was a very industrious man and many of the buildings in existence on Sapelo today were planned and built during his ownership. He created a very grand estate on the island, the epitome of style in the Roaring '20s, entertaining the likes of Presidents Calvin Coolidge and Herbert Hoover. As much energy as he had invested in Sapelo, Coffin only stayed there a short time before throwing himself into the establishment of the Sea Island resort to the south.

The stock market crash of October 1929 hit Coffin rather heavily and he was no longer able to maintain his booming prosperity at Sapelo. In order to keep his Sea Island project solvent, he decided to sell Sapelo for a mere $750,000.

**RICHARD J. REYNOLDS**

Richard J. Reynolds, then a young tobacco heir from North Carolina, purchased Sapelo in 1934. He continued farming and cattle raising activities and expanded the south end complex of buildings. He established a dairy and sold the milk it produced on the mainland.

Reynolds modernized South End House (the Big House, as it's now called) and decorated it lavishly according to his highly personal taste, as Coffin and Spalding had done before him. He was very community minded and renovated the guest house at Long Tabby for use as a summer camp for boys.

Like his predecessors on Sapelo, Reynolds enjoyed experimenting and he introduced Brahmin cattle to the island and practiced diking marshland for agriculture. He added several new buildings to the south end including the dairy complex, which surrounded a courtyard and fountain, two boathouses and seven residential houses. These buildings now house the University of Georgia Marine Institute and its faculty.

Reynolds had a keen interest in research and supported the formation of the Georgia Agricultural and Farming Research Foundation in 1949, renamed the Sapelo Island Research Foundation in 1959. He hosted and sponsored conferences in marine and estuarine science until his death in 1964.
AFRICAN AMERICAN COMMUNITIES

After the Civil War, several settlements were established by freed slaves who were granted property on Sapelo by Union General William T. Sherman’s No. 15 order of January 1865. These self-sufficient communities at Raccoon Bluff, Shell Hammock, Behavior and Hog Hammock engaged in agricultural or timber activities. Many of their citizens became indebted to financial speculators who took advantage of them. The island was eventually recovered by the Spalding family and it is thought that all blacks who were not Spalding slaves or their descendants were forced to leave Sapelo.

Raccoon Bluff, sold to freed blacks in 1871, had been part of Picot de Boisfercullet’s holdings and was later owned by Anson Kimberly of Darien, Ga., until he died in 1836. His heirs retained the property until 1871. Raccoon Bluff is the only part of Sapelo never to be owned by the Spalding family. The first self-sufficient community was established there in 1866. Raccoon Bluff is the site of the First African Baptist Church, established in May 1866. In 1898, community members constructed a church from lumber that had floated ashore from the ruins of the South Atlantic Quarantine Station’s hospital on the south end of Blackbeard Island. The hospital had been destroyed by the hurricane of October 2, 1898. This church still stands, but the congregation built a new church in Hog Hammock in 1970.

Behavior was a large slave settlement whose site now holds a four-acre black cemetery. Shell Hammock, located at the south end, is now the Marine Institute area.

Hog Hammock, the only one of the communities still in existence, was named for a Spalding slave named Sampson Hog, who raised hogs. The site name Hog Hammock appears on the local maps from as early as 1857. Between the late 1940’s and 1960, all blacks on the island were consolidated from the various communities into residence at Hog Hammock by R.J. Reynolds. The 434-acre settlement once boasted a population of over 300.

Because of its isolation, the unique African American culture that developed on Sapelo has been preserved in much the same state that it was in the last century, with the exception of modern conveniences. Electricity and television did not come to Hog Hammock until 1967. Today most of the residents live in small frame houses with tin roofs or in trailers. Some of the residents of Hog Hammock still speak Gullah, a musical language comprised of bits of many languages spoken by European colonists as well as the African dialects the slaves brought with them.

The number of Sapelo residents has declined with each generation as young people leave the island in search of jobs. The only opportunities for employment on the island are a few positions with the DNR and various maintenance positions with the University of Georgia Marine Institute. Recently, several residents have been raising clams, renting trailers and rooms to overnight guests and selling handicrafts to tourists. Today, 75 permanent residents remain.

Because of its isolation and lack of commercialism, many outsiders desire to build on Sapelo and Hog Hammock has begun to experience land speculation. The DNR and the residents of Hog Hammock have initiated efforts to curb or stop this land speculation and new development in order to preserve this unique cultural and natural heritage.
MARINE INSTITUTE

R.J. Reynolds wanted Sapelo to be utilized for marine research, so he invited the University of Georgia to propose a program for this purpose. UGA scientists George Boyd, Eugene Odum and Donald Scott prepared a proposal for a marine biology lab for research into biological productivity in the coastal waters and wetlands.

In July 1953 funds for facilities and operating costs became available and the first scientists came to Sapelo to begin research. They were housed in existing buildings at the dairy complex and the dairy barn was converted to a laboratory. This operation evolved into the University of Georgia Marine Institute, whose continuing purpose is marine and estuarine research and education.

In 1969 the state of Georgia purchased the north end of Sapelo and established the R.J. Reynolds Wildlife Refuge. In December 1976, the state bought about 5,000 acres on the south end from the Sapelo Island Research Foundation, and this combined with the existing wildlife refuge was designated the Sapelo Island National Estuarine Sanctuary (now the Estuarine Research Reserve), which is currently regulated by the National Oceanic and Atmospheric Administration. The only part of the island not now state-owned is Hog Hammock, which still belongs to the descendants of the African Americans who have lived there since Spalding's time. The island and its facilities are wholly dedicated to marine research and preservation.

The UGA Marine Institute has lease on south end lands to conduct research and monitoring experiments. The institute does not directly control access to the island but its influence is responsible for the island's limited visitation access in order to preserve ecosystem integrity for research.

MANAGEMENT

Sapelo is now administered by the Georgia Department of Natural Resources. The Wildlife Resources Division administrates north end activities, the Richard J. Reynolds Wildlife Management Area, the passenger ferry system and non-game activities pertaining to eagle hacking and seasonal monitoring of sea turtle activity. The Reynolds Wildlife Management Area operates a primitive hunting camp on the island through which visitors may camp, fish from docks and hunt in designated areas. Wildlife Resources Division also manages the Sapelo Island National Estuarine Research Reserve, the Cabretta Pioneer Campground and runs the Big House as a conference center for environmental organizations, federal and state government agencies and the business and academic communities. This division conducts the educational efforts of the Reserve as well as its research and administration functions. The Reserve employs the following on-island staff: Reserve Manager, Education Coordinator, Research Coordinator, Interpretive Assistant, Office Manager. Off-island staff include the Visitors Center manager, clerk and ticket coordinator. The Visitors Center is Sapelo Island's mainland base of operations for shipping delivery and island visitation. Coastal Resources Division monitors public oyster reefs on the West side of Sapelo Island for contaminants and disease.
MANAGEMENT UNITS

Management Units

- R.J. Reynolds WMU
- Natural Area
- Marine Institute
- Reserve
- Hog Hammock
Points of Interest

1. Marsh Landing
2. University of Georgia Marine Institute
3. Main House
4. Lighthouse
5. Pavilion, Nannygoat Beach
6. Hog Hammock Community Center
7. Cabretta Bridge
8. Raccoon Bluff Church
9. Bourbon Field
10. Duck Pond
11. Shell Ring - Indian Mound
12. Chocolate - Tabby Ruins
13. Moses Hammock Hunt Camp
14. Lumber Landing
15. DNR and SINERR Office US Post Office
SAPELO: A CONFLICT OF INTERESTS

OBJECTIVE: By taking part in this simulation game, the students will improve their analyzing, communicating, decision making, problem solving and valuing skills.

INSTRUCTIONS FOR THE TEACHER:
(This activity should be conducted only after the history of the island has been studied and several of the activities have been conducted and ideally after a trip to the island. If you are unable to make a trip to the island, you may want to show the video: "The Spirit of Sapelo" which can be rented or purchased from the Department of Natural Resources)

1. Photocopy and give each student a copy of all roles.
2. Explain to the students that they will be taking part in a simulation game depicting a town hall meeting to decide what, if any, changes should take place on Sapelo Island. They will be playing a role (acting) where they present or argue a point of view that may or may not be their own. Regardless of how they actually feel, they must portray the role they are assigned.
3. Assign one student the role of Chairman of county commissioners. Discuss with this student the amount of time you will be allowing for the town hall meeting. (We recommend that you allow two to three class periods for this activity). This student is in charge of conducting the town hall meeting and the decision making meeting of the county commissioners.
4. Assign 16 other students the roles of the various interest groups: hunter, local citizen, non-native land owner, Hog Hammock resident in favor of no change, Hog Hammock resident in favor of some change, local motel owner, educator, UGA Marine Institute representative, shrimper, chamber of commerce member # 1 and # 2, bank president, land developer, Friends of Sapelo representative, DNR/SINERR representative, and DNR Game Management Section representative.
5. Assign the remaining students the role of the county commissioners.
6. Tell the students that they should study their roles and be prepared to conduct a town hall meeting where they will present the position of the interest group they represent. They may use the roles as printed or make up their own. If they make up their own it must convey a similar message as the printed role. The students should also study the roles of the other participants and be prepared to ask questions after everyone has presented their position.
7. Your role as the teacher is to mediate if necessary and to make sure the students stay on task. You may want to play "the devil's advocate" and ask pertinent questions if the students do not do so.

FOLLOW-UP DISCUSSION:
1. Ask the students how they felt about their role. Did they actually agree with the concerns of the role they portrayed?
2. Discuss if they agree with the descision(s) of the county commissioners. Was the decision fair to all the interest groups? If not, what was sacrificed? By whom?
3. Did all groups sacrifice the same thing? Different things of equal or similar importance?
4. Discuss the difficulties of placing an economic value on certain recreational pursuits and aesthetic aspects of life.
TOWN HALL MEETING ROLES

Hunter:
I have been hunting on Sapelo for about eight years now. My fellow hunters and I really like the solitude here and our rustic hunting camp at Moses Hammock. This is our time to get away from the city and enjoy nature as well as to hunt. It is OK with us if more people come to Sapelo, but we are concerned about their safety. Someone could wander into the hunting area and get shot. If that did happen, hunting might even be discontinued on Sapelo and that would really be a shame. You do need to remember that hunting is not only a sport for the hunter but it also helps to keep the deer and turkey populations under control. Sapelo needs hunters and our needs should be considered in any plans for the island.

Local Citizen:
I am here representing a group of local citizens. We do not want to interfere with anyone, but we do want to be able to go over to Sapelo and go to the beaches. This is our state and our beaches and we want to be able to take our children, grandchildren and friends over for a day of picknicking and enjoying the beach. It certainly would be nice if transportation were offered from the dock to the beach. We do not care if it's provided by the state or the people of Hog Hammock, and we certainly do not mind paying. We just want to be able to get there. We have no intentions of bothering the scientists and their experiments or the people of the island. I'm sure if signs were put up telling where the experiments were, no one else would bother them.

Non-native Land Owner:
I represent a small group who have been able to obtain property in Hog Hammock. We obtained our land either from Hog Hammock residents, from their descendents, or through bank foreclosures. We feel that our land was obtained perfectly legally and that we have a right to build homes and live or vacation on Sapelo. Most of us have no desire to harm or change Sapelo or its people. People need to realize that if we had not bought our land, it could have been purchased by people who did not care for the island as we do. We also want to be able to let our friends use our Sapelo homes & cars when we are not on the island.

Hog Hammock Resident in favor of no change:
I represent the people of Hog Hammock that do not want more people coming to Sapelo. This is our home and was the home of our fathers and their fathers. We do not appreciate all the people coming here and interrupting our way of life. We do not want our culture and heritage destroyed by outsiders coming in. The more people that come here, the more that will want to come here and try to buy our land from us. People coming here and building homes or condos will cause our property taxes to go up and many of us will probably lose our land. We just want to be left alone. If people want to know more about us and our way of life and heritage, they can hire us to come to the mainland and speak to their groups or we'll sell them our baskets. We do not want development on Sapelo.

Local Motel Owners:
I represent the owners of local motels. We certainly hope that more people do come to our community and we hope they will stay in our facilities. If motels were built on Sapelo, that would take business away from us. We will be glad to work with school groups and give them discounts on rooms. We could arrange for our restaurants to prepare box lunches. We could even put in video arcades or work-out rooms so the students would have something to do in the evenings. And of course, we all have swimming pools. We would not be interfering with the Hog Hammock people having their trailers, but we could handle the larger groups and there would be no need to disrupt the community by building on the island. We will gladly advertise DNR tours and sell Sapelo baskets in our gift shops. We would like for the people that visit Sapelo to spend some time in the local area.

County Commissioners:
Your job is to listen to the concerns and ideas of all the interest groups. You should be prepared to ask questions of each group representative about how what they want could best be accomplished. Your task is to come to a decision with the other county commissioners that will satisfy as many of the interest groups as possible. If you cannot come to a definite decision, you can decide to form a committee or committees to study various situations further. The commissioners will then have to delay their decision until all committees have presented their reports.
**UGA Marine Institute Representative:**

Most people do not realize the importance of our work on Sapelo. The Marine Institute is world renowned for its research on estuaries. It is because of our research that laws have been passed protecting estuaries and other wetland areas. These areas are not wastelands, they are very fertile lands that are a major source of food, although indirectly, for most all the organisms that live in the ocean. Also most ocean creatures spend at least part of their life cycles in the estuaries. Estuaries actually affect all of us, not just those who eat seafood. Many, many jobs ultimately depend on a healthy estuary such as truck drivers, Sea Pack workers, grocery store owners and employees, gas station attendants, etc. We really do not want a lot of people coming over to Sapelo. People just do not understand that they must stay out of the marsh and off the dunes. We have experiments going on in various places around the island and they could easily be ruined. We have even had to start locking our building because people were wandering in. We cannot risk someone disrupting an important experiment or injuring themselves while nosing around where they have no business. Sapelo is perhaps one of the most undisturbed areas along the GA coast. Our research into this area can help establish standards by which other coastal areas are measured. The more people/activity on the island, the more associated impacts and the more degradation to the natural system. This lowers the standard and makes Sapelo less effective as a standard measure. We are very busy and often do not have time to speak with groups visiting the island.

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**Educator:**

I represent the educators in Georgia and we would like it made easier for us to bring our students to Sapelo. We need transportation for small as well as large groups. It would be nice if there were a snack bar or small cafeteria but we don't mind bringing our own food. We would like to have some type of dorm and lab facilities available for older students. The dorms at UGA are no longer used, why couldn't they be re-opened for school groups? Some of us like to do our own teaching, but some of us are unfamiliar with the island and need a Naturalist available. We would like to see teacher workshops available, so that we can better educate our students. We would like to have people available to work with our students on science fair projects and would be willing to work with the DNR or UGA, on some long term projects. There are facilities at Skidaway, Jekyll Island, and Honey Creek for us to take our students, but those are on very developed islands. If we want to preserve our undeveloped or uncommercialized islands, then the public needs to be educated on the importance of them. Before one can understand, one must experience. We as educators can help preserve our islands only if we have the opportunity to let our students experience them.

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**Shrimper:**

I am here representing the local shrimpers and crabbers. Most of us have lived in this community all our lives as have our fathers and their fathers before them. Our business is dependent on a plentiful supply of shrimp, crabs and fish and they depend on a healthy estuary. My fellow shrimpers and crabbers add a tremendous amount of money to the economy of this community and even the state. There is already a building boom in this area and the water is becoming muddier from run-off from the construction sites. Now, we don't mind more people coming in because they buy our shrimp and my wife really likes the convenience of the new shopping center. The waters around Sapelo are very clean and a good place to shrimp. We don't want it messed up with mud from construction. We almost got put out of business over having to change our nets to add TEDS and the competition of the Florida Shrimpers coming to Georgia. We certainly don't need our fishing areas ruined by some rich people coming in and building their fancy homes and motels on Sapelo. We also don't want any more regulations on our industry.
Chamber of Commerce Member # 1:

I am here representing many of the businesses in the community. Our businesses depend on residents and tourists spending money. The more people who come here and spend money, the higher our profits. For years, this area was overlooked and many of us lived in near poverty conditions, so we are in favor of anything that attracts more people to our area. We need all the industry, motels, and housing developments we can attract to bring in more jobs and money to our people. The new outlet mall is a start and it has brought many jobs and positive recognition to our area. Sapelo is just one more resource for us to use to attract money. If a few people lose their homes, so be it. Times are changing and I for one plan to change with it and make as much money as I can.

Chamber of Commerce Member # 2:

I am here representing the local marina, small boat captains and kayak and canoe shop owners. We agree that times are changing and yes, we are benefiting financially from the people that are coming to our neighborhood. Our businesses also depend on the natural beauty of the waters around Sapelo and neighboring islands. We take people out fishing, canoeing and kayaking. We also make a lot of money on the supplies we sell. If too much development takes place here, the very thing that attracts people to this area (the fish, quiet waters and natural beauty) will soon disappear and the people I represent will lose their livelihoods. A little development is fine, maybe even necessary, but we must not overdo it. I am sure that there is some way we can reach a compromise that will be acceptable to most of us.

DNR nd Sapelo Island National Estuarine Research Reserve Representative:

I am here representing the DNR and Sapelo Island National Estuarine Research Reserve (SINERR). In December of 1976, Sapelo became a National Estuarine Sanctuary and has been protected by law. SINERR and the DNR work together to ensure the preservation of the fragile ecosystems on the island. Our primary purposes are to protect the natural and cultural resources on the island, to allow and support scientists in their investigations on how the estuarine system functions and to promote and encourage public education. We conduct two to three guided tours of the island each week and encourage the public to visit the island for nature study, low intensity recreation, hunting, fishing and camping. We also provide transportation and tours for school and other educational groups. We have a new interpretive center on the mainland and a nature trail on the island. We have expanded our educational offerings with a new curriculum guide for teachers to use with their students. We encourage more school groups to come to Sapelo, although we cannot at this time offer any overnight facilities other than our newly upgraded campground at Cabretta. The "Big House" is available for small adult educational conferences. Should funds become available in the future, more facilities could be considered. Until then, the local motels are willing to work with school groups that want an extended visit to the island. In 1994, over 6,000 people attended programs or public tours on Sapelo. Although we encourage more people to visit and experience what Sapelo has to offer, our job is to protect the land and waters from stress and alteration. We cannot and will not encourage any development that would harm the fragile habitats or the integrity of Hog Hammock.

DNR Game Management Section:

I am here representing the Game Management Section of DNR. Our job is to manage the Ferry, hunts, law enforcement and essential services such as water, sewage, and trash removal. The ferry runs several times a day and we make special or additional trips for special occasions and church services. The trips we currently make are sufficient at this time to handle additional passengers. The cost to passengers is only $1.00 per trip. We offer eight hunts on the island each year. These are well received and the hunters have use of the hunt campground at Moses Hammock. We also have refrigeration facilities for the deer and turkey they kill. The water system on Sapelo is already inadequate and costly to maintain, with more hook-ups we will likely see the need to replace the system. Water availability and quality are huge concerns for the barrier islands and in the future it is going to be more expensive for us to supply that water. The dumpsters we have for trash collection are almost filled to capacity considering our current barge schedule (we barge the dumpsters off the island). I guess what I am saying is that we can handle the amount of people that we have on and visiting the island now, but with our present funding and staff, we can not handle any more people on Sapelo. At the present time crime is moderate although we do now have a law enforcement officer. If we have a large influx of people coming to Sapelo, it may be necessary to increase enforcement.
Bank President:

Well, I think we all need to be realistic about this matter. Everybody here in one way or another uses my bank or some other bank. It is my job and that of other bank presidents to provide services for the people of the community, but the bottom line is: we are in business to make money. One thing we all have to realize is that times are changing and we have to change with the times if we are going to survive financially. We need to attract more industry and business to this area so that we will have jobs for everyone and so my bank can make money. I do not see a thing wrong with more building on Sapelo. Why Sapelo could be another Hilton Head and just think of the tourists and business it could attract to our community. We could build a lot of buildings on Sapelo and still have it be a nice 'natural' setting. We are missing a huge opportunity to develop this island! I say, if we do not change with the times and take advantage of the opportunities we have to make money, we will all live to regret it.

Land Developer:

I'm not sure that you in this community realize what a gold mine you have here. Sure, I know most of the island is owned by the State or the Reynolds Foundation, but, Hey, you've got over 400 prime acres in Hog Hammock just crying to be developed. Sure, I know that there are people living there, but most of them are old and with the money that the companies I represent could pay them for their land, they could live in style for the rest of their lives. Why, we would even hire some of the younger ones to work for us. If you would just let us, we could turn the interior of Sapelo into a real showcase. People would be falling all over themselves to come here. The people we would attract would, of course, spend a lot of money on the mainland also. Of course, we would have to cut down some trees and widen some roads to handle all the traffic. We would have to dredge some of the tidal creeks so that they would be deep enough for our tour and party boats. Some of the natural areas would be harmed or destroyed in the process, but such is progress. We could make this island rival anything on Hilton Head, St. Simons or Sea Island. It would be great for the economy of this area. I have a staff of people just chomping at the bit to work on the designs for this island and backers to buy the property. All you have to do is say the word and our people will start buying up the land.

Chairman of County Commissioners:

Your job is to conduct the town hall meeting. First, discuss with your teacher the length of class time to be allotted for the town hall meeting. You should arrange the room for the meeting. You should call the meeting to order, state the purpose of the meeting, and tell each interest group how much time they have to present their views. You should also allow time for the county commissioners to ask questions of each interest group. Each group should also be allowed to ask questions of each other. You should call time on any group that goes over their allotted time and mediate any arguments that arise. After each interest group has presented their views and the county commissioners have had time to ask questions, instruct the county commissioners to retire to their meeting room (another area in the classroom) to make their decision or recommendations. As chairman, you also lead this meeting. Remind each commissioner that it is their duty to make a decision that will be in the best interest of everyone or as many of the interest groups as possible, as well as for Sapelo. The decision or recommendations of the county commissioners should be presented to the entire class along with reasons to support each decision or recommendation.

Representative from The Friends of Sapelo:

As a member of the volunteer group "Friends of Sapelo," I am concerned about preserving the natural and cultural uniqueness found on Sapelo Island. Most of us are volunteers because we love nature and we love coming to the island to help out with programming or improvement projects. The 'Friends' want to be sure that we are granted continued access to the island. The SINERR coordinates our activities but we undertake projects that benefit the island as a whole. Too much access to the island might mean that access is denied to groups like us who are trying to be a positive impact on the island. We are opposed to activities that would inhibit the educational and research projects on Sapelo. As Sapelo continues to grow, we are working to make sure that the community of Hog Hammock and the unspoiled beauty of Sapelo are preserved.
BARRIER ISLANDS

SECTION-B
BARRIER ISLANDS

WHAT ARE THEY?

Barrier islands are among the most beautiful and precious features of our coastline. A barrier island is defined as a long, offshore, dune-covered deposit of sand lying roughly parallel to and separated from the mainland by a shallow sound (lagoon) and/or salt marsh; barrier islands are separated from each other by tidal inlets. Our present barrier islands have evolved over thousands of years and are a wonderful example of a delicate but balanced system in a constantly changing environment.

Thirteen percent of the world's coastlines and more than one-third (33%) of the coast of North America is bordered by barrier islands. Along the Atlantic coast alone there are more than 300 barrier islands and spits (a spit is similar to a barrier island but is smaller and attached to the mainland) extending along the coasts of 18 states from Maine to Texas. Each barrier island is different and unique in its own way and although no two are exactly alike, they may have many similarities.

A typical mature barrier island consists of several distinct features or habitats including the ocean, beach, berm, primary dunes, secondary dunes, interdune meadows, shrub zone, maritime climax forest, salt marsh, tidal (or mud) flats and sounds. Many barrier islands also have freshwater sloughs that form in low areas and between old dune ridges. Each habitat, although existing in close proximity to the others, has its own unique characteristics.

IMPORTANCE OF BARRIER ISLANDS:

Barrier islands are called "barrier islands" because they create a barrier between the mainland and the ocean. They shelter and protect the mainland from the powerful forces of wind, waves, tides, currents and the ravages of storms and hurricanes. They shelter the estuaries that form behind the barriers. Between 75% and 95% of all marine species are dependent upon these estuaries at some point in their lives. They allow marshes to build up in the quiet waters of the sound. The marshes filter the pollutants that come in from mainland rivers and when the marsh grasses die they create detritus, a valuable food source for small marine organisms.

Barrier islands provide valuable habitats for mammals, shellfish and fish including many endangered species, and offer a greater variety of bird species than any other ecosystem in the continental United States. They also serve aesthetic purposes and for years, have inspired artists, poets, writers, birdwatchers, boaters, picnickers, sunbathers and swimmers.

Barrier islands are truly a most valuable resource. It is remarkable that although they constantly change and may become badly eroded (some even disappear entirely), they can rebuild if left alone.
BARRIER ISLAND GEOLOGY AND FORMATION:

There are several theories as to how barrier islands form. Georgia's barrier islands are thought to have formed as the result of world-wide sea level fluctuations caused by alternating periods of warm and cold during the Pleistocene Epoch that allowed great continental ice sheets to advance and retreat over the Northern Hemisphere. During glacial advances, huge amounts of water were locked in glaciers causing the sea level to fall. Then, during interglacial periods when it was warmer, the ice melted, causing sea level to rise.

Georgia was never covered by glaciers but it was affected by the rising and falling of the sea level about 40 million years ago. During the Pleistocene, in warm periods, sea level may have been as much as 50 to 100 feet higher than today with the ancient coastline lying along a sand ridge known as Trail Ridge. During times of extreme cold, the shoreline lay as much as 80 miles seaward of its current position.

One theory suggests that Georgia's present barrier islands may have formed during several consecutive periods of glacial melting. The older islands formed thousands of years ago when sea level rose flooding the coastline. (Dates for their formation are unclear and could have been anywhere from 25,000 to 100,000 years ago.) Ridges of sand dunes were left above sea level and gradually built into barrier islands. Over the next few thousand years sediments from rivers added material to fill in the area between these new islands and the mainland producing mud in which the vast expanses of salt marsh formed. As sea level stabilized these small remnants of old sand dunes gradually built into our older barrier islands. About 11,000 years ago near the end of the Pleistocene, sea level rose again, flooding the coastline to its present location. About 5,000 years ago the rise in sea level slowed to about four to six inches per century, allowing the formation and growth of our newer Holocene islands. Over the last few thousand years sediments from rivers and the islands' natural landward migration have filled in or partially filled in the area between these older and younger sets of islands. Today sea level is rising a little more than one foot per century.

Each period of ice formation and melting created a new sequence of barrier islands along the coast of Georgia. The oldest series of islands, the Wicomico Shoreline, formed when sea level was as much as 95 to 100 feet higher than it is today and is responsible in part for the creation of the Okefenokee Swamp. The next series of barrier islands, called the Penholoway Shoreline formed when sea level was 70 to 75 feet above its present level. The Talbot shoreline formed when sea level was 40 to 45 feet higher; the Pamlico shoreline formed when sea level was 25 feet higher. The Princess Anne shoreline formed when sea level was 15 feet higher; the Silver Bluff shoreline formed when sea level was 5 feet higher.

Carbon dating of shells found on Sapelo Island shows the main part of the island to be between 25,000 and 36,000 years old. The present day beaches, Nannygoat and Cabretta, are only 4,000 to 5,000 years old.
BARRIER ISLAND MIGRATION AND NATURAL EROSION

WHERE DOES THE SAND COME FROM?

The sand of Sapelo and Georgia's other barrier islands originated mostly from the erosion of the Appalachian Mountains. Three hundred million years ago, the Appalachian Mountains stood at least three miles high. Soon after their formation and for millions of years since, constant erosion has all but flattened these once majestic mountains. The sediments from the mountains were carried by streams to rivers and eventually deposited in the ocean. As the seas rose and fell with the rise and fall of water due to the glacial advances and retreats, the sands from the once majestic mountains were swept back and forth from the edge of the continental shelf to Trail Ridge (Georgia's fall line), creating a series of barrier island ridges that filled in and eventually created Georgia's coastal plain.

The sand on today's beaches is mostly quartz and mica with deposits of some heavier minerals including ilmenite. Other heavier minerals include zircon, epidote, tourmaline, sillimanite, kyanite, hornblende, garnet, and rutile, though only in very small quantities. Once the sands reach the ocean they are picked up by longshore currents that run from north to south along the coast. These longshore currents, along with the action of waves and tides, add sand to (accretion) and remove it from (erosion) the beaches of our barrier islands.

THE SAND SHARING SYSTEM:

Barrier islands survive because they are flexible. They must remain in a constant state of change in order to overcome the constant rise and fall of sea level. For example, for every one-foot rise in sea level an island may move 100 to 1,000 feet inland. Once a barrier island has formed, the action of the winds, waves, tidal currents, and longshore currents causes dynamic changes in its size and shape. It may retreat toward the mainland, migrate along the coast, or build toward the ocean.

All of the barrier islands along Georgia's coast are integral components of a complex system of sand sharing that enables each island to continue to exist. Each island, though unique in its characteristics, is dependent on all the other islands for its existence.
Sand is brought to Georgia's coast as sediment that has been eroded and transported from hundreds of miles inland. Major river systems including the Savannah, Ogeechee, Altamaha, and Satilla rivers carry the sand seaward. These major rivers and many smaller rivers add sand and silt to the sand sharing system. When these rivers reach the ocean, their sediments of sand and silt are deposited at the mouths of the rivers. Here the sand and silt is picked up by longshore currents and carried southward. The waves and tidal currents constantly work and rework the sand from offshore sandbars to the beach and back, and from island to island.

Sand also can be transported from one island to the next.

What one island loses, the next one gains. Waves approach the beach at an angle, and when they strike the beach they pick up particles of sand. These suspended sand particles are carried to the surf zone where they are picked up by longshore currents and carried downshore. This longshore sediment transport is called the littoral drift. The general direction of the littoral drift on Georgia's islands and the east coast of the United States is from north to south although, like all other coastal forces, it may vary daily or monthly.

During the winter months, strong winter waves and storms created by strong northeast winds, remove sand from the beaches. These storm waves carry sand from the beach and deposit it on the continental shelf in a series of offshore sandbars. These submerged offshore runnel and trough systems simply store the sand until the gentle fair weather waves of summer push the sand through these ridge and runnel systems back toward the beach where it is redeposited onto the beachface. When the sand dries out during low tide, it is picked up by the wind and carried to the upper beach where it is trapped by pieces of shell, wrack and plants that are above the high tide line, forming new dunes.
Large storm waves may sometimes push sand through gaps in the sand dunes or sometimes even across an entire island. This sand is deposited in the areas between the dunes or sometimes in the marshes. This process, called overwash, allows the islands to roll over themselves and move landward, sharing sand from the ocean side of the island with the landward side. Overwash also provides fresh sand for the dunes.

In general, the north end of an island receives sand from an adjacent island. Then this sand is eroded by the strong winter waves from the north end and transported along the island through the sand sharing system and deposited in a series of sandbars at the southern end of the island. These sandbars gradually build into spits that are attached to the island and fill in, adding to the length of the island. On Sapelo, most of the northend erosion is occurring on Blackbeard Island which is considered part of the Sapelo sand sharing system.

The tidal rivers and inlets that separate each island interrupt some of the sand being carried by the littoral drift. Tidal currents move sand back and forth between the islands daily and some of the sand becomes permanently trapped in the quiet waters of the shallow sounds that are landward of the islands. Once in the quiet waters of the sound, the finer sand and silt or clay particles settle out, creating mud deltas. Over time (many years), these mud deltas build up, forming a base on which marsh grasses begin to grow, thus widening the island toward the mainland.

Georgia's barrier islands are located about 80 miles farther west from the continental shelf than the barrier islands to the north and south. Looking at a map of the east coast of the United States, it looks as if something has taken a bite out of the coast. The westward indentation from the Outer Banks of North Carolina to Miami is called the South Atlantic Bight. The area from Cape Fear to Cape Canaveral is called the Georgia Bight. This farther westward location causes the waves that strike Sapelo and Georgia's other barrier islands to have a lower wave energy than other barrier islands. The larger waves break farther out (approx. 80 miles) at the continental shelf. This low wave energy and the strong tidal currents cause Georgia's islands to become short and thick with a "drumstick" shape and causes the inlets between the islands to be wide and
stable. Georgia's coast is said to be a "mesotidal" coast, which means it is dominated by tides. Georgia has a tidal range from seven to 10 feet. This large tidal range creates tidal currents that fill in the areas landward and also helps to create wide beaches. These wide beaches have more sand available for dune formation.

Because of their farther westward location, most of Georgia's barrier islands are less susceptible to hurricanes than islands farther north or south. Hurricanes that affect the east coast of the United States form in the warm waters of the Caribbean. As the storms move northward, they tend to follow a narrow corridor of warm air created by the Gulf Stream which lies some 80 miles off the coast of Sapelo near the continental shelf. Most hurricanes hit land either in Florida or in the states north of Georgia where the width of the continental shelf is narrower and the Gulf Stream is closer to land.
THE BEACH IS MOVING

OBJECTIVE(S): 1. To investigate the sand sharing system and the natural movement of sand along the coast.
               2. To investigate the effect of man made barriers to the movement of sand.

MATERIALS:  
- transparent sweater box, rectangular glass baking dish, or bread pan
- block of wood
- modeling clay
- sand
- water

BACKGROUND INFORMATION:

Waves strike the beach at an angle and the water becomes trapped behind offshore sandbars and travels down the coast from north to south in longshore currents. These longshore currents pick up some of the sand that is being carried from the beach to the offshore sandbars and carries it south in a process called longshore transport. The natural beach erosion on Georgia's islands is from the north to the south. The longshore currents carry sand eroded from the northern end of an island and carries it southward and deposits it at the southern end of the island and eventually to the next island down the coast. Sometimes man adds barriers to the southward movement of this sand. These barriers may be in the form of dams that prevent sand from reaching the ocean so that it can be deposited onto the beaches by the waves and longshore currents. Other features like jetties and sea walls are often built to try to prevent the natural movement of sand and to stop the erosion of the beach near homes and hotels.

PROCEDURE:

1. Create an island of sand along one side of the container. The island should cover about half the length on the container.
2. Carefully place water in the container.
3. Using the block of wood, create waves that approach the island at an angle from the north.
4. Continue creating waves for several minutes and record what happens to the beach.
5. Reconstruct your island and this time build a jetty out of modeling clay that extends into the water at the center of your island. The jetty should be just a little higher than the water level.
6. Create waves again using your wood block wave generator. After several minutes record your observations.
7. Try building additional jetties along the island to see if more than one jetty has a different effect on the island. Record your observations.
8. Build a sea wall a couple of inches inland on your island. Create waves. Record your observations on the effect of the seawall.
9. Build a series of T-jetties along your island. Create waves again. Record your observations on how the effect of the T-jetty compares to the effect of jetties that extend straight out into the water.

**OBSERVATIONS:**

1. Describe what happened to the island when the waves were first created.

2. After construction of the jetty, what happened?

   How did this compare to what happened to the sand before the jetty was created?

3. Did the addition of multiple jetties increase or decrease the effect of the first jetty? Explain how.

4. What effect did the building of the seawall have on your island? Did it stop erosion? Explain.

5. Describe the effect of the T-jetties on the island. How did it compare to the effect of the jetties built straight out into the ocean?

**CONCLUSIONS:**

Explain the natural movement of sand along an island. Describe the effect of man made structures on the speed of erosion on islands.
THE SHIFTING SHORES OF SAPELO

PURPOSE: 1. To investigate how the beaches on Sapelo have changed from 1940 to 1992.
2. To investigate how the tidal creeks of Sapelo have changed over time.
3. To explain beach migration using the sand-sharing system.

MATERIALS: 4 different colored pencils (with very sharp points)
tracing paper
Barrier Island Migration and Natural Erosion fact sheet
drawings of Sapelo: 1940, 1953, 1974, 1992

PROCEDURE:

1. Read the Barrier Island Migration and Natural Erosion fact sheet.
2. Lay a sheet of tracing paper over the 1940 drawing of Sapelo and color in the two black circles (●). These will be your guide points to match up the other drawings.
3. Trace the 1940 map in one color. Make a key to designate which color represents which year.
4. Move your drawing to the 1953 map and match the black circles with the ones you colored in. Trace the 1953 map with a different color. Add this color to your key.
5. In the data table, describe the changes in the shape of the island. What parts have eroded? What parts have accreted? What changes have taken place in the tidal creeks and rivers?
6. Move your drawing to the 1974 map, line up the black circles and trace the map using a third color. Add this color to your key. In the data table, describe the changes to the island between 1940 and 1974, and between 1953 and 1974.
7. Move your drawing to the 1992 map. Line up the circles and using a fourth color trace this map. Add this color to your key. In the data table, describe the changes to the beach and tidal creeks and rivers.
8. Answer the questions.

DATA TABLE: Use an additional sheet of paper if necessary.

<table>
<thead>
<tr>
<th>Changes in shoreline from 1940-1953</th>
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<tr>
<td>Changes in tidal creeks and rivers from 1940-1953</td>
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<td>Changes in shoreline from 1940-1974</td>
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<td>Changes in tidal creeks and rivers from 1940-1992</td>
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<td>Changes in shoreline from 1974-1992</td>
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NOTE: The maps used in this activity were adapted from maps drawn by Dr. Alice Chalmers of the University of Georgia Marine Institute on Sapelo Island.

B-10
ANSWER THE FOLLOWING QUESTIONS:

1. What changes do you see on the shoreline of Sapelo between 1940 and 1953?

2. What major changes occurred to the tidal creeks between 1940 and 1953?

3. Describe the changes in the island between 1953 and 1974.

   What major changes occurred between these years to the tidal creeks and rivers?


5. Between 1940 and 1992, what were the major changes in the tidal creeks and rivers of Sapelo?

6. From 1940 to 1992, what parts of the island have experienced accretion?

   What parts have experienced erosion?

7. What factors (natural or otherwise) may be responsible for this accretion and erosion? (Consider that every island along Georgia's coast is affected by what happens on or to the other island above it).

8. At one time, there were three distinct beaches on Sapelo (Cabretta, Nanny Goat, and the South end beach). Between what years did these three beaches become two? __________

   Which two beaches became one? ____________________________  What could have happened to have two beaches instead of three on Sapelo?

9. In 1949, the cabanas, now located well behind the dunes, were at the edge of the primary dunes. What has happened to this section of the beach?
10. Observe the maps of 1940 and 1953. Note the changes in the position of the island. Compare these changes to the changes in position of the island between 1974 and 1992. During which period of time was there greater change? ____________________ What factors may have contributed to this change?

11. In what direction(s) is Sapelo migrating? (Toward the ocean, southward, or toward the mainland).

12. For years, locals have fished and seined in "The Big Hole," an area between the north end of Nanny Goat Beach and the south end of Cabretta. In recent years, the fishing has not been as good and the locals say "The Big Hole is drying up." Compare the 1974 and the 1992 maps and applying what you have learned about island migration and the sand-sharing system, explain what is probably happening to decrease the size of "The Big Hole" and the quality of the fishing there.

**CONCLUSION:** Using the information gained from reading the information on the sand-sharing system and island migration and from this activity, describe where the major changes on Sapelo have taken place. Explain how or why these changes have occurred.
BATHYMETRIC MAP OF SAPELO'S CONTINENTAL SHELF

PURPOSE: To make a contour map and profile map of a portion of the continental shelf off the coast of Sapelo Island.

MATERIALS: Bathymetric Map of Sapelo pencil

BACKGROUND: Scientists measure the depth of the ocean floor by using echo soundings called sonar. These sonar soundings are then used to generate bathymetric maps that show the depth of the water. Ships, Shrimpers, boaters, etc. use these maps to navigate through coastal waters. The depths on bathymetric maps are recorded at mean low water.

TERMS TO KNOW:

Contour lines: lines connecting points of the same depth. They give an idea of the shape of the land or sea floor. Contour lines that are close together represent a steep slope. The farther apart contour lines are, the gentler the slope.

Contour Maps: show contour lines indicating the shape (topography) of the land or seafloor.

Mean Low Water: the average of the depth of water at low tide.

Continental shelf: the land under water, actually part of the continent, that extends from the shoreline to the continental slope (the actual edge of the continent).

Contour interval: the distance between contour lines.

Fathom: a unit of depth measurement. 1 fathom = 6 feet or about 2 meters

Nautical mile: 1.151 miles.

The bathymetric map you will be using in this activity is only a portion of nautical chart # 11509 and can be obtained from the U.S. Department of Commerce, NOAA, National Ocean Service, Silver Springs, MD. 20910. Chart # 11511 may also be used.

The soundings or numbers on the map are in feet at mean lower low water (the average of the lowest of low waters). The scale of the map is 1:80,000.

Use the scale below for measuring nautical miles on your map:
PART I: CONTOUR MAP OF THE CONTINENTAL SHELF OFF SAPELO ISLAND

PROCEDURE:

1. Using a pencil and beginning at the south end of Sapelo follow the solid line drawn for you connecting the areas that would be 5 feet deep. Notice that in many cases you will have to guess where the proper points are. In one area, you will find the # 5 representing 5 feet and in other areas you might see a 4 next to an 8. The 5 foot line would be between the 4 and the 8 but closer to the # 4.

2. Using the contour interval of 5 feet, draw your next contour line along the 10 foot depth, the next along the 15 foot depth. Continue drawing the contour lines 5 feet apart until you reach the edge of your map.

3. Answer the questions in the observations.

OBSERVATIONS:

1. How far from shore in nautical miles was your deepest contour line? (Measure from Nanny Goat Beach [X] on the southern end of Sapelo)

2. If 1 mile = 1.151 nautical mile, how many miles from shore is this deepest point?

3. How deep was the water?

4. Figure the average depth per nautical mile.

5. What would the average depth per mile be?

6. According to your contour lines, would you say that the continental shelf off the coast of Sapelo has a steep or gentle slope? Explain your answer.

7. Why would a ship need a bathymetric map to navigate off the coast of Sapelo or any other island?
PART II: PROFILE MAP OF THE CONTINENTAL SHELF OFF THE COAST OF SAPELO

PROCEDURE:

1. In the chart below, place a dot (.) at the depth of the seafloor at each nautical mile indicated.
2. Connect the dots to form a profile map of Sapelo's continental shelf to that depth.
3. Answer the questions in the observations.

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OBSERVATIONS:

1. The deepest part of the continental shelf shown is ________ feet? ________ fathoms?
2. Three nautical miles from shore the depth of the continental shelf is ________ feet?
3. How deep is the continental shelf three statute miles from shore?
4. How deep is the water 20 nautical miles from shore? ________ feet ________ fathoms
5. How far is the depth in question # 4 in statute miles?
6. Many marine organisms make their home in and on the sands of the shallow water off the coast of Sapelo. How would these organisms be affected if there were a shipwreck which left a major oil spill? Explain your answer.

CONCLUSION: Explain what a bathymetric map and profile map are and how they are used. Who should know how to read these types of maps and why?
THE BARRIER ISLANDS OF GEORGIA
THE BARRIER ISLANDS OF GEORGIA

TYBEE ISLAND

Tybee Island is the farthest north of Georgia's barrier islands. It is approximately four miles long and one mile wide and was built by sands brought in by the Savannah River. Tybee's total acreage including marsh is 3,100 acres, 1,500 acres of which are non-marsh. The island has three and one-half miles of beach.

The name Tybee is an Indian word meaning salt. Historical sites include the Tybee Lighthouse (completed in 1773 and rebuilt in 1867) and its accompanying museum, and Fort Screven, which dates to 1875.

Tybee is Georgia's most developed barrier island. The commercialism on Tybee consists of hotels, year-round private residences, summer cottages, condominiums and various tourist facilities, such as public bathing beaches, fishing piers, marinas and public campgrounds.

Tybee is an excellent place to view and study an island that has been greatly altered by man's activities. Because of man's destruction of the dunes, building too close to the ocean and the building of jetties and seawalls, Tybee has undergone a great deal of erosion. The dredging of the shipping channel of the Savannah River has starved the beach of sand and has accelerated its erosion. The landward side of the island has a great deal of marsh left but only a few areas of maritime forest and natural dunes remain.

Although there have been several recent attempts to combat the erosion, only a few cases have been successful. The jetties and seawalls that were built to prevent erosion actually increased it. Several attempts at renourishment have not been as successful as hoped. Snow fences have been added in several places and were only moderately successful in the building of new dunes. On the north end of the island attempts to grow dune plants have also been moderately successful and some small dunes are forming. In March of 1995, a series of T-jetties were placed at the south-end of the island. T-jetties have been proven to work in slowing erosion elsewhere and, hopefully, they will help Tybee.
LITTLE TYBEE

Little Tybee, once privately owned, was recently acquired by the State of Georgia, with a conservation access allowed to the Nature Conservancy. The island has approximately three and one-half miles of beach with a total acreage of 6,505 acres only 600 of which are non-marsh or upland. The only access to the island is by private boat and as yet there is no development.

WILLIAMSON ISLAND

Known as Georgia's newest island, Williamson Island was first detected around 1971 and later claimed by the State of Georgia. It formed by the growth of a sand bar or detached spit off the south end of Little Tybee and the sand is thought to have come from the erosion of Tybee. Its current length is approximately two miles. The island was named for Mr. Jimmy Williamson, a former Mayor of Darien, Georgia.

WASSAW ISLAND

This seven-mile-long island is the most primitive and undeveloped of Georgia's barrier islands. In 1866, a New England cotton merchant, George Parson, purchased the island for $2,500. Later, Parson's descendants sold it to the Nature Conservancy with the understanding that no bridge would ever be built to it from the mainland. In 1969, the Nature Conservancy deeded Wassaw to the federal government as a National Wildlife Refuge. Since 1973, the Cabretta Research Project has conducted research on population levels and habits of loggerhead turtles at Wassaw. From mid-May through mid-September, volunteers observe and tag nesting female loggerheads and relocate threatened nests to protected hatchery sites.

2,500 of Wassaw's 10,050 total acres are upland and the island has six miles of beautiful unspoiled beaches. One of Wassaw's most interesting features is the "boneyard beach" on the northeast end of the island. Here hundreds of live oaks, pines and cabbage palm trees have fallen prey to erosion and now their "skeletons" line about a mile-long stretch of the beach. Erosion at the north end has also partially exposed the remains of an 1898 fort to the tides. Another interesting feature is the 50-foot-high dune line, which was created by the hurricane of 1890. Hundreds of gulls, herons, egrets, migratory songbirds and shorebirds use the beaches, marshes and freshwater ponds as breeding and nesting grounds.

Seasonal deer hunting is allowed by permit only and most of the island is open to the public during the daylight hours. The middle 180 acres of the island are still owned by the Wassaw Island Trust and are not open to the public. Access to the island is by private or commercial boat charter.
OSSABAW ISLAND

Ossabaw Island is 10 miles long and two miles wide with an area of 25,000 total acres, 11,800 of which is upland. It has nine and one-half miles of beaches.

Ossabaw is extremely rich in history and was once a favorite hunting and fishing ground of the Indians. Skeletal remains of Indians dating back 4,000 years have been found there. Early colonists hunted the island as early as 1687. The island was bought by the Torrey family in 1924. Mrs. Eleanor Torrey West and her husband founded the Ossabaw Island Project Foundation in 1961. The foundation invited artists, authors, ecologists, musicians, sculptors and scientists to work on the island and share their ideas. In 1978, Mrs. West sold the island to the State of Georgia as a Natural Wildlife Refuge and in May of that year Ossabaw became Georgia's first Heritage Preserve under the Heritage Trust Act of 1975. As a Heritage Preserve, Ossabaw can be used only for natural, scientific and cultural purposes. Mrs. West still lives on the island in her family mansion and works with the DNR in the management of the island.

In the Wildlife Refuge section of the island, seasonal hunting is permitted. There is no bridge to the island and public visitation is very limited. Special permission for primitive camping or to stay in Mrs. West home can be obtained however, through Mrs. West or the DNR.

ST. CATHERINES ISLAND

St. Catherines is a 23-square-mile island with a total acreage of 14,640 acres and 11 miles of natural beaches. The total upland acreage is 6,870 acres.

Once the capital of the Guale Indian Nation, St. Catherines was also the site of Santa Catalina de Guale, the first Spanish mission in coastal Georgia (1566). The first book written in Georgia was an Indian grammar book written at St. Catherines by a Jesuit friar in 1568. Button Gwinnett, one of the signers of the Declaration of Independence, bought the island in 1765 and lived there until 1771. His 19th century family home and slave cabins are still standing.

St. Catherines is currently owned by the private non-profit J. Nobel Foundation. Since 1968, the St. Catherines Foundation, along with the American Museum of Natural History and the New York Zoological Society, has conducted archaeological and zoological research and rare and endangered wildlife breeding there. Breeding colonies of nearly extinct species from several continents have been established, including cockatoos, gazelles, Madagascar turtles, heartbeests, and parrots.

Visitation to the island is by private boat and by invitation only, due to the sensitive nature of the research being conducted there.
BLACKBEARD ISLAND

Blackbeard Island's total acreage including marsh is 5,618 acres. It has 3,900 acres of uplands, 9 miles of beach, and is two and one-half miles wide at its widest point.

In the early 1700s Edward Teach, the famous English pirate popularly known as "Blackbeard," was thought to have buried treasure on Blackbeard Island. Sapelo's Allen Green, who at one time worked on Blackbeard, once discovered a large chain around a live oak tree. The chain extended into the ground near a tidal creek. Could this chain have been attached to Blackbeard's treasure? We will never know.

In 1800, Blackbeard Island was purchased by the U. S. Navy Department at public auction as a source of live oak lumber for shipbuilding. From August 14, 1880 to 1910, the island served as a quarantine station where ships left passengers that were thought to have yellow fever. A hospital was built on the southern end of the island because of the lack of standing water. It consisted of a large wooden storehouse and several large tents. Tents were used because they could be burned easily after infestation with the disease.

In 1924, Blackbeard Island became a preserve and breeding ground for native birds when it was placed under the jurisdiction of the Bureau of Biological Survey which later became the U. S. Fish and Wildlife Service. In 1940, it was proclaimed as the Blackbeard Island National Wildlife Refuge.

Blackbeard is open to the public for daytime recreational activities and bow hunting is allowed during bow season with the proper permits. Freshwater fishing is allowed from March 15th to October 25th with a Georgia fishing license. Access to the island is by boat only and the government dock on Blackbeard Creek is accessible during all tides.

SAPELO ISLAND

Sapelo is about 12 miles long and two to four miles wide with a total area of 17,950 acres, making it the fourth largest of Georgia's barrier islands. Sapelo has 10,900 acres of uplands and five and one-half miles of undeveloped beaches. Sapelo's Nannygoat beach is noted for having the most extensive undisturbed natural beach dunes of any of Georgia's barrier islands.

Sapelo Island is jointly owned by the State of Georgia, the R. J. Reynolds Foundation and the residents of the Hog Hammock Community. Sapelo is a National Estuarine Research Reserve.
and Wildlife Refuge. The Department of Natural Resources, the National Oceanic and Atmospheric Administration and the R. J. Reynolds Wildlife Refuge share the management duties of the island. At the south end of Sapelo, the University of Georgia Marine Institute conducts research in barrier island formation and salt marsh ecology. Primitive camping and short term lodging is offered through the residents of Hog Hammock and the DNR.

See Sapelo History for more detailed information about Sapelo and its history.

WOLF ISLAND

Wolf Island is located just south of Sapelo at the mouth of the Altamaha River. It has a total of 5,126 acres, of which only 250 acres are high ground including beach and dunes. Three and one-half miles of beach line the ocean side of the island.

In 1930, Wolf Island was purchased by the federal government. Wolf Island National Wildlife and Natural Wilderness system includes not only Wolf Island but Egg and Little Egg Islands as well. Access to the island is by boat and only limited public recreation activities are allowed in order to protect the nesting grounds of the least and royal terns, shorebirds, wading birds, migratory waterfowl and loggerhead turtles.

LITTLE ST. SIMONS

Little St. Simons Island is the last family-owned island on Georgia's coast. One of its most famous owners was Pierce Butler and his wife Fanny Kemble, who grew rice there during Georgia's plantation days. It was purchased in 1908 by Philip Berlzheimer and his descendants still own the island and operate a retreat where overnight guests are invited to visit to fish, hunt, horseback ride, canoe, take nature tours, and enjoy its six and one-half miles of beaches.

The island has a total acreage of 8,840 acres including marsh. 2,300 of these acres are uplands. The island has excellent examples of fresh and brackish water ponds that serve as habitats for more than 200 species of birds.

SEA ISLAND

Sea Island is connected by causeway to St. Simons Island and is a privately owned beach resort with hotels and private cottages and residences. Development of Sea Island began in 1926 when Howard Coffin bought five miles of beach front and established the Sea Island Co. to
develop a first-class resort. The five-star Cloister Hotel opened in October of 1928. Today the island has five and one-half miles of beach and 2,000 total acres including the marsh. The upland acreage is 1,200 acres. Because of its private ownership, there is no public access to the beach from the mainland.

ST. SIMONS ISLAND

St. Simons is the only one of Georgia's larger barrier islands that has never been privately owned. St. Simons consists of 27,300 total acres including the marsh. It has 12,300 upland acres and three miles of beach. St. Simons and Sea Island together are 13 miles long and 4 miles wide.

St. Simons is extremely rich in history, having been inhabited first by the Creek Indians and then by the Spanish, British, and finally by southern plantation owners who grew sea island cotton and live oak timber. Historic points of interest include Fort Frederica, Fort St. Simons, Christ Church, Bloody Marsh, Hamilton Plantation, Hampton Plantation, Cannon's Point Plantation, and Retreat Plantation and the St. Simons Lighthouse. The lighthouse, first constructed in 1810 and rebuilt in 1871, is one of the nation's oldest continuously working lighthouses. After the Civil War, St. Simons became a much-loved resort. The causeway was built in 1924 and the airport in 1934. The Coast Guard Station which closed in 1996 was built in 1937. Today most of the island is privately owned residential homes and low-key commercial hotels and condominiums. Its fishing pier attracts visitors from miles around and serves as the center for many of the activities of the local village.

JEKYLL ISLAND

Jekyll Island, the smallest of Georgia's major barrier islands, is 10 miles long and one and one-half miles wide at its widest point. It has 5,700 total acres, 4,400 of which are uplands. It has eight miles of beach.

Jekyll was first used as hunting and fishing grounds by the Creek Indians who called the island "Ospos." In 1562, the island was claimed by the French Huguenots and the name was changed to "Ile de la Somme." In 1566 Spanish Jesuit priests established a mission there. In 1736, after claiming the island for Britain, General James Oglethorpe established an outpost and renamed it Jekyll after his friend Sir Joseph Jekyll. In 1738, Oglethorpe placed the island in the care of his aide Captain William Horton. In 1742, after the defeat of the Spanish, Jekyll was held as a military reservation until it was added to the Parish of St. James by the Georgia legislature in 1765. In 1766, the island was granted to Clement Martin, who sold it to Richard Leake in 1784. In the early 1790s the island was purchased by Christopher Poulain du Bignon. The island remained in the duBignon family for nearly a century and was used to grow sea island cotton. In 1886, Jekyll was purchased by a group of northern millionaires including the Rockefeller, Morgan, Pulitzer, Vanderbilt, Gould, McCormick, Goodyear, Aston, Baker, Biddle, Whitney, Armour, Crane, Macy and Bliss families for use as a winter resort. In 1947, the state of
Georgia bought Jekyll for use as a state park. The causeway and bridge were built in 1954, allowing easy access for the general public to enjoy year-round recreational activities.

Jekyll offers an excellent environment in which to study island erosion and accretion. Due to the dredging of the St. Simons Sound, the north end of Jekyll is experiencing rapid erosion. The south end, however, is experiencing accretion, including the building of a beautiful dune field.

**LITTLE CUMBERLAND ISLAND**

Little Cumberland Island is owned by a private homeowners association. The island has two and a half miles of beach and 2,400 total acres, 1,600 of which are uplands.

**CUMBERLAND ISLAND**

Cumberland Island is the southernmost and longest of Georgia's barrier islands. Including the marsh, it has a total acreage of 23,000 acres, 15,000 of which are uplands. The island is one and a half to three miles wide and has 17.5 miles of beach.

Cumberland was once inhabited by a Florida tribe of the Timucuan Indians who called the island Missoe which means sassafras. The island was renamed San Pedro by the Spanish who settled, set up a mission and occupied the island for more than a century. It was named Cumberland in 1734 by Chief Tomochichi in honor of his friend William Augustus, Duke of Cumberland. In 1738, the British built Fort William or Prince Williams Fort at the lower end of the island and Fort St. Andrews at the northern end. General Oglethorpe built a hunting lodge near Fort William and named it Dungeness after the royal county seat upon the "ness" in the County of Kent. Between 1765 and 1768, James Cuthbert, Jonathan and Josiah
Bryan, John Smith and James Habersham were given royal grants on the island. After the Revolutionary War, Cumberland became part of Camden County.

For several years, Cumberland was used as a hideout by smugglers and one small neighboring island is still known as Hush-Your-Mouth Island. During the plantation days (approximately 1780s - 1860) several plantations prospered including the Stafford Plantation and Dungeness (home of General Nathaniel Greene). These plantations fell into ruin after the Civil War and were deserted until 1882, when a large part of the island was sold to Thomas Carnegie of Pittsburgh. The Carnegie family rebuilt the Dungeness mansion in 1880 and other family members built Plum Orchard in 1898, the Stafford Place and Grey Field in 1901. Around 1900, W. P. Bunkly built the Hotel Cumberland on the northern end of the island called High Point. This property later became the property of the Candler family of Atlanta.

Portions of Cumberland were donated to the National Parks Service in 1970 and by an Act of Congress in 1972 it became a National Seashore. In 1982, the northern half of the island was added to the National Wilderness Preservation System. Today the island is managed by the National Parks Service and day trips and short-term camping are available. No more than 300 people are allowed to visit the island per day. There are still several private residences on the island and the Grey Field Inn, a private commercial facility, offers overnight accommodations.
HOW DOES SAPELO COMPARE?

PURPOSE: To compare Sapelo Island with the other barrier islands of Georgia in total acreage, acreage of uplands, acreage of marsh, and miles of beach.

MATERIALS: Fact Sheets on The Barrier Islands of Georgia and Sapelo History

PROCEDURE:

1. Use the information in the fact sheets to fill in the data table.
2. Answer the questions in the observations.

OBSERVATIONS: Use the information in your data table to answer the following questions. (NOTE: To calculate the marsh acreage you must subtract the upland acreage from the total acreage)

1. How many total miles of beach do the islands listed have? __________________________
2. How many total acres of uplands exist on Georgia's barrier islands? ____________________
3. How many total acres of marsh exist on Georgia's barrier islands? ____________________
4. Which island has the most miles of beach? __________________________
5. Which island has the most total upland acreage? __________________________
6. Which island has the most total marsh acreage? __________________________
7. Which island has the least total upland acreage? __________________________
8. Which island has the least marsh acreage? __________________________
9. Which island is the longest? __________________________
10. Which is the shortest island? __________________________
11. How many islands can be reached by automobile? __________________________
Name them.

12. Which islands are developed commercially? __________________________
13. Which islands are privately owned? __________________________
14. Which islands cannot be developed further commercially because they are protected by state or federal government ownership?

15. On which islands is research being conducted? __________________________
16. Which islands can be visited by the public? __________________________
17. How does Sapelo compare to the other islands in: (rank as 1st, 2nd, 4th, 5th etc.)
   length? __________________________
total acreage? __________________________
miles of beach? __________________________
acres of marsh? __________________________
acres of uplands? __________________________
18. Who owns Sapelo?
19. Can Sapelo ever be developed commercially? __________________________ Explain your answer.
In Georgia, the coastline is a vital resource. Understanding the importance of the coastline and the knowledge of the importance of marshes, explain why it is important for Georgia to preserve its coastline.

Using the information gained from this activity, and your knowledge of the importance of marshes, explain why it is important for Georgia to preserve its coastline.

**Conclusion:** Summarize how Sapelo Sound, to the other islands along Georgia's coast.

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<th>Length (miles)</th>
<th>Total Acres</th>
<th>Commercial Area (acres)</th>
<th>Access to Beach (miles)</th>
<th>Access to Marsh (acres)</th>
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<tr>
<td>Williamson</td>
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<tr>
<td>Tybee</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Data Table:**

(use boxes if necessary)
EFFECTS OF WAVES, CURRENTS AND TIDES

In order to understand the changing nature and migration of Gorgia's barrier islands, one first must understand the dynamic forces responsible for the migration. Waves, tides and currents all play important roles in the movement of sand on islands. These forces also play a key role in the distribution of food, nutrients, oxygen, temperature, salinity, plankton and all forms of marine life.
WAVES

Anything that causes water to move can cause a wave: earthquakes, underwater landslides, changes in atmospheric pressure, underwater volcanic eruptions, the movement of ships, or even a fish jumping. The most common cause of surface waves in the ocean, however, is the wind blowing across the water. Once set in motion by the wind, as long as the wave is in deep water, the energy of the waves is passed from water particle to water particle without the water actually moving. The size of a wave depends on how long the wind blows, the strength of the wind, and the distance the wind blows, known as the fetch. (Remember how long, how strong, how far.)

The energy of the wave not only moves forward but also moves the water up and down as well. The water in a wave moves in a circular pattern downward to a depth of one-half the wavelength. As long as the wave is in water deep enough for it to complete its downward wave motion, only the energy of the wave is passed forward, not the water.

When waves near shore, they change because the water molecules can no longer complete their downward orbital motion. As the depth of the water decreases, the bottom of the wave begins to feel drag and the energy movement in the wave slows down, shortening its wavelength. This flattens the circular wave motion into an oval shape. The back of the wave is now traveling faster than the front and overtakes it, forcing the wave into a peak. The wave breaks or spills over when the depth is less than one-half its wavelength.
When a wave breaks it does move the water. The water rushing onto a beach is called a wash or swash and the water returning to the ocean is called a backwash or undertow. As the water rushes onto the shore it picks up loose particles of sand and carries them backward as it rushes back out to sea. Some waves transport sediment to the beaches. The wash brings sand up onto the beach but the gentle backwash is not able to carry as much sediment back to the ocean. These waves result in deposition or building of the beaches.

All waves have the same measurable characteristics. The highest part of a wave is the crest. The lowest part is the trough. The vertical distance between the wave crest and trough is the wave height. The distance from a certain point on one crest or trough to the same point on the next crest or trough is the wavelength. The amplitude of a wave is the distance the wave moves the water above or below sea level and is equal to one-half the wavelength. The wave period is the time it takes for succeeding crests to pass a specified point.

Georgia's coast has only moderate wave energy, the lowest along the southeast Atlantic coast. Because of Georgia's gently sloping and wide continental shelf, the water deepens gradually and much of the wave energy is dissipated before it reaches Georgia's beaches. The average height of a breaking wave on Georgia's coast is nine to twelve inches.
CURRENTS

Currents are rivers of water in the ocean. The two major types of currents are surface currents and density currents.

Surface currents are driven by the wind. Friction between the wind and the water sets these currents in motion. The winds that drive surface currents are the Westerlies that blow west to east at 40 degrees to 50 degrees latitude and the trade winds that blow east to west at 20 degrees latitude. Surface currents occur in near shore waters with a maximum depth of 100 to 200 meters. They are shaped by the Coriolis effect, the pull of gravity and the position of the continents. As the earth rotates, both air and water currents are deflected to the right (clockwise) in the Northern hemisphere and to the left (counterclockwise) in the Southern hemisphere. If a surface current originated in warm latitudes, its waters are warm and it is called a warm current. Those that originate near cold latitudes become cold currents. The air above a current is either warmed or cooled by the water and therefore currents have an important effect on the climates of the land areas near them.

A special type of surface current is a longshore current. Longshore currents occur along a coastline. They are caused in the following way: waves strike the shore at an angle and the water accompanying the waves tries to rush back out to sea. Along the shoreline of barrier islands is a series of offshore sand bars that stops the movement of the water back to the ocean and causes it to flow parallel to the shore between the shore and the offshore bar. These longshore currents are responsible for transporting sand from the north to the south end of our barrier islands and from island to island.
The water in these longshore currents will eventually flow back out to sea. When the currents reach a break in the offshore sand bar they will rush through the narrow opening, creating a rip current or undertow. If ever caught in a rip current, swim across it; never try to swim against a rip current.

Density currents flow in deep water. They are denser than the water around them and gravity causes them to sink. The density of the water is affected by both the temperature and the amount of dissolved substances in the water. Cold water, which is more dense than warm water, will sink. Salt water is more dense than fresh and will sink below fresh water. Rivers entering the ocean carry large amounts of sediment with them. River water is less dense and comes out on top of the denser salt water. As the velocity slows, the sediments are dropped to the bottom.

The positions of the continents also affect the flow of currents. The water cannot flow through the continents, so it flows around them creating great circles or gyres that flow clockwise in the Northern hemisphere and counterclockwise in the Southern hemisphere.

Each current has its own characteristic salinity, density and temperature. The major currents affecting Sapelo and Georgia's other barrier islands are longshore currents and the Gulf Stream, a warm current, that flows northward a short distance off the continental shelf.
TIDES

Tides are huge "waves" that are caused by the gravitational attraction between the earth, the moon and, to a lesser extent, the sun. High tide is the crest of the wave and low tide is the trough of the wave. All objects have a gravitational attraction to each other. The amount of gravitational attraction between two objects depends on how close together they are and how large they are. Because the moon is closer to the earth it has a greater effect on the earth's tides than the sun does, even though the sun is much larger. Sir Isaac Newton, in his Universal Law of Gravitation, explains this. His law states that the pull of gravity is directly proportional to the product of the masses of the two objects and inversely proportional to the square of the distances between them. The sun, even though much larger than the moon, is only 46 percent as effective in producing tides because its distance from the earth is so great.

The earth revolves around the sun once every 365 days. It rotates on its axis once every 24 hours. The moon revolves around the earth once every 29 days. As the moon revolves around the earth, the gravitational attraction of the moon pulls the earth's water toward it. This causes tidal bulges, which are bulges of water that occur on the side of the earth facing the moon. The earth's rotation creates centrifugal force that causes another, almost equal, bulge to occur on the opposite side of the earth. When these bulges hit land and the water piles up, the land under the bulges experiences high tides, while the land not under the bulges experiences low tide.

High tides occur approximately 50 minutes later from one day to the next because in the 24 hours that it takes the earth to rotate once, the moon has moved about 12 degrees in its 360 degree orbit around the earth. Since the moon is orbiting in roughly the same direction as the earth is rotating, it takes an earth based observer another 50 minutes to get to a point where the moon is in about the same position overhead.

Twice during the moon's 29 day orbit, the earth, moon, and sun are in a straight line. This alignment occurs at the new and full moon phases. At the new and full moon phases, the combined gravitational pull of
the sun and moon creates higher than average high tides and lower than average low tides. These tides are called **spring tides**. If the sun and moon are both on the same side of the earth, the spring tide will be even higher.

When the moon is at right angles to the earth and the sun in its orbit around the earth (at the first and third quarter phases) the gravitational attraction of the sun and moon almost cancel each other, causing lower than normal high tides and low tides that are higher than average. These tides are called **neap tides**.

The vertical difference between high and low tide is called the tidal range. Georgia's average tidal range is seven feet. The spring tidal range for Georgia is 10 feet.
Most areas on Earth have two high and two low tides per day, which are slightly more than six hours apart. Two high and two low tides of equal magnitudes are called semi-diurnal tides. Georgia and most of the east coast of the United States experience semi-diurnal tides. Areas with two high and two low tides of unequal magnitudes have what are called mixed tides. These occur along the Pacific Coast of the U.S. and part of the Gulf of Mexico. Areas with only one high and one low tide per day have diurnal tides. Certain parts of the Gulf of Mexico have diurnal tides.

TIDAL CURRENTS

Tidal currents called ebb and flood tides are important for several reasons. Flood tides or flood currents bring in fresh seawater to the marsh. They flush inlets and channels, preventing the water from becoming stagnant. Ebb tides or ebb currents remove sediments, detritus, and nutrients from the backwaters of the marsh and carry them to the estuaries. Tidal currents also wear away the shorelines and create new land when they deposit sand and silt. These tidal currents create
unique habitats and the organisms that live there must have special adaptations in order to survive alternating periods of inundation and dryness.

TIDE TABLES AND CHARTS

Tides can be predicted because the orbit of the earth and moon and the slope of the ocean floor are predictable. The National Oceanographic and Atmospheric Administration (NOAA) of the United States Department of Commerce publishes tide charts and tables that list predicted time and magnitude of daily tides for many locations on the coast of the United States. The tide tables are available from the National Oceanic and Atmospheric Administration, Distribution Branch, 6501 Lafayette Ave., Riverdale, MD 20737, (301) 436-6990. Tide tables may also be obtained from bait shops, marinas, or in tourist pamphlets.

Tide tables illustrate the rhythmic nature of tides and give detailed information on daily tides for specific areas. They give the time and magnitude of high and low tide as well as the time during which the tide is coming in (flooding) or going out (ebbing). The heights are measured in reference to "mean low tide" or the average of all the low tides over many years. For example, if the height of a tide is listed as 2.5, this means that the tide will be 2.5 feet above mean low tide. If the height of a tide is listed as -0.5, it will be 0.5 feet below mean low tide. Tide tables are only predictions. Natural conditions such as winds and storms can cause the heights to be higher or lower than predicted.

Those who live near the coast are aware of the importance of knowing when high and low tides occur. Shipping, boating, fishing, navigation of shallow sounds, beachcombing and sunbathing are only a few of man's activities that are regulated by the tides. If you wanted to go to the beach and there was very little beach available at high tide, you would certainly want to check a tide table for the best time to go. Many tide charts give the time of the tides in military time or local time. So one should know how to use the 24 hour clock. Local coastal areas may offer tide tables in standard time.
INTERTIDAL ADAPTATIONS

OBJECTIVE: To investigate the adaptations of marine organisms which enable them to withstand the power of a crashing wave.

BACKGROUND INFORMATION:

The intertidal zone is a strip of land along an island that lies between the high and low tide line. Animals that live in this harsh environment must have special adaptations because sometimes they are under water and sometimes on dry land where they are exposed to the scorching rays of the sun. Waves are constantly breaking on the intertidal zone. During a storm a wave can hit the shore with a force equal to a car going 90 to 100 miles an hour. Animals living along the shoreline have developed special adaptations that allow them to survive this constant danger of being crushed or washed away by the waves. Some animals and plants have developed special methods of holding on. Whelks have a strong muscular foot, starfish have little suction cups on their arms called tube feet, and mussels and oysters "glue" themselves with tiny threads to a surface. Some animals have adapted their body shape and structure. Whelks, other gastropods and plecypods like bi-valves have a hard shell to protect them. Crabs and barnacles also have a hard exoskeleton for protection. Sand dollars and starfish are flat. Sea anemones and sea cucumbers have strong flexible bodies that enable them to bend without breaking. Some animals also bury themselves in the sand to escape the power of the waves.

MATERIALS: Paper and tape
"THE WAVE"

PROCEDURE:

1. Prepare "THE WAVE" by putting five or more pounds of bird seed or sand or something similar into a pillow case.
2. Using "THE WAVE", demonstrate the power of a crashing wave by dropping the pillow case full of bird seed or sand on the floor.
3. Tell the students to create a creature that can withstand the crushing power of such a wave.
4. They are to create their creature from paper and tape only.
5. The creature must be three dimensional. It cannot be just a flat sheet of paper.
6. Place each of the students creatures on the floor and drop "THE WAVE" onto it.

OBSERVATIONS:

1. Describe the characteristics of the creatures that did not survive "THE WAVE."
2. Describe the characteristics of the creatures that did survive "THE WAVE."

CONCLUSIONS: Explain how animals that live in the intertidal zone are adapted so that they can survive the crushing power of breaking waves.
A BOTTLE OF WAVES AND OTHER WAVEY THINGS

OBJECTIVES: 1. To investigate the parts of a wave.
2. To calculate the frequency and period of waves.

MATERIALS: 2 liter plastic beverage bottle with a screw-on top
blue food coloring
vegetable oil glue
water clear tape

BACKGROUND INFORMATION:

The word wave is used to describe a swell of water as well as energy moving through the water. Waves transfer energy from one part of the ocean to another and as they do so, the ocean water moves up and down. All waves have the same basic characteristics. The crest is the top or highest point of the wave. The trough is the lowest point of a wave. The wavelength is the distance from a point on a wave to the exact same point on the next wave. The wave height is the vertical distance from the highest to the lowest point of the wave. The number of waves that pass a certain point in a given period of time is known as the wave frequency. The wave period is the time it takes for two wave crests to pass a given point.

When a wave moves into shallow water, the trough begins to feel drag along the bottom and it slows down. The crest continues to move forward at its normal speed causing the front of the wave to become steeper than the back of the wave. Eventually the crest topples over and the wave breaks. A wave will break in water that has a depth of approximately one-half the wavelength or about 1.3 times the wave height. Wave speed is calculated by dividing the wavelength by the wave period.
PROCEDURE:

1. Fill the bottle 2/3 full of water.
2. Add the blue food coloring, seal the bottle and shake.
3. Re-open the bottle and fill the rest of the way with vegetable oil.
4. Add a small amount of glue to the sides of the lid and reseal your bottle. Wrap a piece of clear tape around the lid and set the bottle aside to allow the glue to dry.
5. To create waves, lay the bottle on its side and rock it gently. Observe the waves in your bottle.
6. Lay a ruler beside the wave bottle and measure the wavelength and wave height of the waves.
7. Answer the questions in the observations.

OBSERVATIONS:

1. Draw what you see in your bottle. Label the parts of your drawing.

2. Describe each part of the wave that you observe.

3. What is the wavelength and wave height of your wave?

4. What is wave frequency?

   Can you measure the frequency of the waves in your bottle?

   Describe how you measured the frequency.

5. Use these formulas to answer the following questions.

\[
F = \frac{\text{number of waves}}{\text{time in seconds}}, \quad P = \frac{\text{time in seconds}}{\text{number of wave crests}}
\]

A. A seagull floating in the ocean off of Sapelo’s Nannygoat Beach rises and falls 10 times in 20 seconds. What is the frequency of these waves? (remember to express frequency in waves/second)

B. In 60 seconds, 20 wave crests pass a buoy off Sapelo. What is the period of these waves? (remember to express period in seconds/wave)
C. Calculate the wave period and frequency for the following information.

(1) A seagull lands on a channel marker and bobs up and down 32 times in 60 seconds.

(2) A local fisherman noticed a large object bobbing up and down in the water in front of his boat. During the minute and a half that it took him to reach the object, it bobbed up and down 47 times. When he reached the object, he decided to pull it out of the water. He lowered a large hook into the water and reached for the object. He noticed that 17 waves that passed his hook in the 32 seconds it took him to haul the object into his boat.

6. Use the background information and figure # 1 to answer the following questions.

![Figure # 1](image)

A. What is the wavelength of this series of waves? (express your answer in meters) ______  

B. What is the wave height? ______  

C. What is the speed of the waves if the wave period is 4.5 seconds? (Remember that wave speed is expressed in meters/second) ______
7. Use the background information and figure # 2 to answer the following questions:

Figure # 2

A. In what depth of water would a wave break if it had a wavelength of 4 meters? 

B. According to figure # 2, how far from shore would a wave break that had a wavelength of 4 meters? 

C. What would the wave height be for the wave described in A and B above? 

D. What would happen to the distance from shore that the waves were breaking if the wind speed were to increase thus increasing the wave heights? 

CONCLUSIONS: In your own words, describe a wave and explain its parts. How can you calculate the frequency, period and speed of waves in the ocean?
WIND WAVES

OBJECTIVE: To investigate the factors affecting wind waves.

MATERIALS: small aquarium or glass or plastic rectangular container
            hair dryer
            ring stand or doll stand (to position hair dryer)
            erasable markers
            ruler
            water
            tape
            clock or watch

Safety note: do not let any part of the dryer touch the water!!!

PROCEDURE:

1. Place the small aquarium or glass/plastic container on a firm surface.
2. Fill the container about three fourths full of water.
3. Allow the water to settle
4. Tape a ruler on the outside of the container with the zero mark at the waterline. (see drawing)
5. Set the ring stand or doll stand at one end of the container. Attach the hair dryer so that it is a few inches from the edge of the container and a few inches above the water.
6. With an erasable marker, mark the location of the still surface of the water. This should be at the zero mark on your ruler.
7. Turn the dryer on low, note the time you turned the dryer on. Describe these waves in your data table.
8. After 3 minutes, mark the height of the waves on the outside of the container (label this mark A). In your data table, record the height of these waves and describe them.
9. After 5 minutes, mark the height of the waves on the outside of the container (label this mark B). Record their height and description in your data table.
10. Describe what happens to the waves as they hit the end and sides of the container. (place this information in your data table).
11. Turn the dryer off and let the water settle.
12. Turn the dryer on medium speed. Describe these waves.
13. After 3 minutes, mark the height of the waves on the outside of the container (label this mark C). Record their height and description in your data table.
14. After 5 minutes, mark the height of these waves on the outside of the container (label this mark D). Record the description and height of these waves in your data table.

15. Describe what happens to these waves as they hit the end and sides of the container.

16. Turn the dryer off again and let the water settle.

17. Turn the dryer on high.

18. Describe these waves.

19. After 3 minutes, mark the height of the waves on the outside of the container (label this mark E). Record their height and description in your data table.

20. After 5 minutes, mark the height of these waves on the outside of the container (label this mark F). Record their height and description in your data table.

21. Describe what happens to these waves as they hit the end and sides of the container.

22. Turn dryer off!

**OBSERVATIONS:**

Data Table:

<table>
<thead>
<tr>
<th>Dryer speed</th>
<th>Low</th>
<th>Medium (if available)</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of original waves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description of waves after 3 minutes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height of waves after 3 minutes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description of waves after 5 minutes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height of waves after 5 minutes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description of what happens to the waves as they strike the end and sides of container</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Use the information in your data table to answer the following questions:

1. How is the wave height affected by the length of time the wind blows?

2. Describe how the force or strength of the wind affects the height of the waves.

3. What happens to the waves when they hit the end and sides of the container?

4. Does the strength of the waves have any effect on this movement of the waves? Explain your answer.

5. Compare the behavior of the waves that reach the end of the container with those that reach the sides.

6. If your container was twice as long, what effect do you think this extra length would have on the behavior of the waves? (If a larger container is available - try it and see!)

CONCLUSION:

Explain the factors that affect wind waves and how these factors affect the height of the waves.
HOME, HOME ON THE BEACH

OBJECTIVES: 1. To investigate the effects of storm wave action on man made structures on a beach or island.
2. To determine the best place to build a structure on a beach or an island.

MATERIALS: (per group)
- plastic container (stream table, sweater or shoe box, dish pan) large enough to build an island of sand
- milk jug (for water to make storm waves)
- sand
- water
- a variety of materials to build your house (such as shells, sticks, rocks, leaves, grass, straws, cardboard, etc.)

PROCEDURE:
1. Divide the class into 5 groups.

2. In the container provided construct an island out of sand. Include an area behind the dunes, the dunes, and the beach.

3. Using the materials provided:

   Group 1: Build a house or structure on the beach
   Group 2: Build a house or structure directly in front of the dunes
   Group 3: Build a house or structure on top of the dunes
   Group 4: Build a house or structure behind the dunes
   Group 5: Build a house or structure in the middle of the island

4. Take your container outside and using the milk jug simulate a storm. Make sure that the waves from your storm hit the beach at least to the dune line.

5. Record your observations in the data table.

6. Interview a member of each group and obtain information on what happened to their structure. Record this information in the data table.
**OBSERVATIONS:**

Data Table:

<table>
<thead>
<tr>
<th>Group</th>
<th>Location of structure or house on the beach/island</th>
<th>What happened to the structure during the storm?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group E</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use the information in your data chart and what you have learned to answer the following questions:

1. On what part of the island did you build your structure?
2. What type of materials were used to build your structure?
3. Describe any damage that your structure received as a result of the storm.
4. How did your structure hold up compared to the other four?
5. On what part of the island was the structure that received the least damage?
6. On what part of the island was the structure that received the most damage?
7. What factors probably resulted in the most damage?
8. What factors probably resulted in the least damage to the structures?

**CONCLUSIONS:**

Describe what happens to man-made structures on a beach or island during a storm. Explain how the type of construction materials and the location affect the probability of man-made structures to survive the force of waves during a storm.
**WAVE MATH**

**DIRECTIONS:** Use the information in the chart below to determine the average wave height, wavelength, and wave period of these waves that were produced by a storm at sea.

<table>
<thead>
<tr>
<th>WAVE HEIGHT in feet</th>
<th>WAVELENGTH in feet</th>
<th>WAVE PERIOD in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>65</td>
<td>4.3</td>
</tr>
<tr>
<td>3.4</td>
<td>85</td>
<td>4.9</td>
</tr>
<tr>
<td>4.7</td>
<td>100</td>
<td>5.3</td>
</tr>
<tr>
<td>6.1</td>
<td>128</td>
<td>5.9</td>
</tr>
<tr>
<td>7.6</td>
<td>158</td>
<td>6.3</td>
</tr>
<tr>
<td>9.4</td>
<td>180</td>
<td>7.2</td>
</tr>
<tr>
<td>11.2</td>
<td>213</td>
<td>7.4</td>
</tr>
<tr>
<td>13.4</td>
<td>235</td>
<td>7.9</td>
</tr>
<tr>
<td>16.3</td>
<td>264</td>
<td>8.4</td>
</tr>
<tr>
<td>18.6</td>
<td>312</td>
<td>8.7</td>
</tr>
<tr>
<td>21.4</td>
<td>350</td>
<td>9.5</td>
</tr>
<tr>
<td>24.2</td>
<td>400</td>
<td>10.1</td>
</tr>
<tr>
<td>26.5</td>
<td>442</td>
<td>10.7</td>
</tr>
<tr>
<td>30.4</td>
<td>468</td>
<td>11.1</td>
</tr>
<tr>
<td>32.5</td>
<td>495</td>
<td>12.2</td>
</tr>
</tbody>
</table>

**ANSWER THE FOLLOWING QUESTIONS:**

1. Determine the average wave height of the waves produced by this storm.

2. Determine the average wavelength of the waves produced by this storm.

3. What is the average wave period of these waves?
MAKING WAVES

OBJECTIVE(S): 1. To investigate the effect of wave action on a beach.
2. To investigate the difference in summer and winter waves.

MATERIALS: - shallow container (aquarium, transparent sweater box, or rectangular glass baking dish
   - block of wood
   - sand
   - erasable marker or crayon (several colors)
   - container of water

BACKGROUND INFORMATION:

Ocean waves are continually shaping and reshaping the shoreline. Every time a wave rolls up onto the beach it carries sand with it and when it rolls back out to the ocean it carries sand also. In the winter waves are stronger and carry more sand off the beach than they deposit on the beach. The sand that is removed is deposited in offshore sandbars. During the summer, the waves are gentler and carry sand from the offshore sandbars and deposit it back onto the beach. The strong backwash of winter storm waves leaves the beach with a steeper incline than the summer waves, which create a gradual slope.

PROCEDURE:
1. Prepare a beach at one end of the shallow container. It should occupy about one fourth of the container. Slope the sand to look like a real beach.
2. Pour water into your model at the opposite end from your beach. Pour slowly so as not to disturb the sand.
3. Use an erasable marker or crayon and outline the profile of your beach. Draw this profile or cross-section in your observations data table labeled original beach.
4. Using a block of wood as a wave generator, create strong winter waves. Continue this for several minutes until about half of the sand has been removed from your beach. Record your observations.

5. Using a different color of erasable marker or crayon, trace the new profile of your beach. Draw this new profile or cross-section in your observations data table labeled *beach after winter waves*.

6. Using the block of wood again, create some gentler summer waves for several minutes. Record your observations.

7. Using a different color of erasable marker or crayon, trace this new profile of your beach. Draw this profile in your observations data table labeled *beach after summer waves*.

8. Rebuild your beach. This time add a sandbar a short distance off shore.

9. Repeat steps 4 - 7.

---

**OBSERVATIONS:**

Data table:

<table>
<thead>
<tr>
<th></th>
<th>Description of beach</th>
<th>Drawing of beach profile or cross-section</th>
</tr>
</thead>
<tbody>
<tr>
<td>original beach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>beach after winter waves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>beach after summer waves</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. What happened to the sand on the beach after the influence of the stronger winter waves? Where did the sand go?

2. What happened to the beach after the influence of the gentler summer waves? Where did the sand go?

3. Did you notice any evidence of the formation of an offshore sandbar? If so, where did it begin to form?

CONCLUSIONS:

Describe the effect of wave action on a beach. Explain the difference in what happens to the sand after the gentle summer waves and the stronger winter waves.
WAVE SIZE AND DEPTH

OBJECTIVE(S): 1. To investigate how deep the energy of a wave goes.
2. To investigate the relationship between the size and depth of waves.

MATERIALS: an empty aquarium
string
5 corks (the same size and weight)
water
permanent marker
erasable marker, crayon, or wax pencil
2 rulers or one ruler and a strip of wood that will fit inside the aquarium
modeling clay
straight pins

BACKGROUND INFORMATION:

Most waves are generated by the wind. The size a wave becomes depends on how long the wind blows, the strength of the wind, and the fetch (the distance over which the wind blows). The water in a wave moves in a circular pattern downward to a depth of one-half the wavelength or one and one-third the wave height.

PROCEDURE:

1. Using the permanent marker, label each cork: 1, 2, 3, 4, 5.
2. Cut five lengths of string of varying lengths.
3. Tie one end of each string to one of the rulers. Secure the ruler with the strings attached to the bottom of the aquarium with modeling clay.
4. Attach the corks to the strings with straight pins so that one cork is an inch from the bottom of the aquarium. Another cork should extend one inch farther up from the bottom, etc. One cork should be very close to the surface. Record the depth of each cork in data table #1.
5. Add water to the aquarium until it is about one inch above the cork with the longest string.
6. Make small waves by moving your hand back and forth in the water. Observe each cork and place your observations in the data table #1.
7. Increase the size of the waves. Observe how this affects the corks and place your observations in the data table #1.
8. Let the water stand until it is smooth (no waves). With an erasable marker, mark the level of the still water on the outside of the aquarium. This line represents sea level.
9. Hold a ruler vertically beside the aquarium and make small waves with your hand again. Measure the height and depth of these small waves. Make larger waves again and measure their height and depth. Record this information in data table #2.
DATA TABLE #1:

<table>
<thead>
<tr>
<th></th>
<th>Cork #1</th>
<th>Cork #2</th>
<th>Cork #3</th>
<th>Cork #4</th>
<th>Cork #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of cork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of Small waves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of Larger waves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DATA TABLE #2:

<table>
<thead>
<tr>
<th></th>
<th>Height above sea level</th>
<th>Height below sea level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small waves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Larger waves</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OBSERVATIONS:

1. When waves were small, which corks moved?
2. When waves were larger, which corks moved?
3. How deep did the effect of the small waves go? The larger waves?
4. Is there a relationship between the depth of the effect of the waves and the wave height?
   Explain your answer.

CONCLUSIONS:

In your own words, explain how deep the effect of the energy of a wave can be felt and the relationship between wavelength and height to wave depth.
CURRENTS

OBJECTIVE: To investigate the causes of currents in the ocean.

MATERIALS: (per group)

- 2 baby food jars or small glass containers
- posterboard squares (about 3 inches square)
- dishpan or container to catch water
- tap water
- warm tap water
- food coloring
- plastic spoon
- ice
- salt
- paper towels

PROCEDURE A – SALINITY CURRENTS:

1. Place both jars in the dishpan.
2. Fill both jars with tap water (fill to the top).
3. In one jar place 1/2 to 1 teaspoon of salt. Add a little salt, stir until it dissolves, add a little more salt, stir etc. up to one teaspoon.
4. Add several drops of food coloring to the saltwater jar.
5. Place the posterboard square on top of the saltwater jar and invert it.
6. Place the inverted salt water on top of the freshwater jar.
7. Line up the lids so that they meet.

8. Working over the dishpan, one student should hold both jars in place while another student removes the cardboard square.
10. Repeat steps 1-9 with the freshwater on top. Remember to observe what happens and to record your observations.

11. Repeat steps 1-9 with both jars horizontal. Remember to observe and record your observations.
OBSERVATIONS FOR PROCEDURE A – SALINITY CURRENTS:

Data Table #1:

<table>
<thead>
<tr>
<th>Position of jars</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Diagram 1]</td>
<td></td>
</tr>
<tr>
<td>![Diagram 2]</td>
<td></td>
</tr>
<tr>
<td>![Diagram 3]</td>
<td></td>
</tr>
</tbody>
</table>

Answer the following questions:

1. What happens to the salt water (where does it go)?

2. Is salt water heavier (more dense) or lighter (less dense) than fresh water? __________
   Use the information gained from your observations to support your answer.

3. Based on your observations, what happens to river water when it flows into the ocean?
   (Explain this in terms of salinity)

4. Freddy the fisherman was fishing his favorite spot near the mouth of the Darien River. His first catch was a freshwater brim caught immediately after he cast in his line. He cast his line in again. After about 5 minutes, he reeled in a saltwater croaker. Freddy was so excited about catching both a fresh and saltwater fish at the same location that he decided to go directly to the sports editor of the Darien News and tell him. Do you think that Freddy's catch was as exciting as he thought? Should he go to the sports editor? Base your answer using the observations you made in procedure A.
PROCEDURE B -- TEMPERATURE CURRENTS:

Working over the dish pan again:

1. Fill one jar with warm tap water. Fill the other jar with cold tap water and add several ice cubes. Stir the cold water until the ice dissolves. If after several minutes the ice is not totally dissolved, but the water is cold, remove the remaining ice from the jar.
2. Add several drops of food coloring to the warm water.
3. Place the posterboard square on top of the jar of warm water, invert it and place it on top of the cold water.
4. Line up the lids so that they meet.

5. One student should hold both jars in place while another student removes the posterboard square. (Do this as carefully as possible, trying not to spill the water.)
6. Observe what happens and record your observations in data table #2.
7. Repeat steps 1 - 5 with the cold water on top.

8. Observe what happens and record your observations in data table #2.
9. Repeat steps 1 - 5, this time hold the jars horizontal.
10. Record your observations in data table #2.

OBSERVATIONS FOR PROCEDURE B -- TEMPERATURE CURRENTS

Data Table #2:

<table>
<thead>
<tr>
<th>Position of jars</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image 1" /></td>
<td><img src="image2.png" alt="Image 2" /></td>
</tr>
<tr>
<td><img src="image3.png" alt="Image 3" /></td>
<td><img src="image4.png" alt="Image 4" /></td>
</tr>
<tr>
<td><img src="image5.png" alt="Image 5" /></td>
<td><img src="image6.png" alt="Image 6" /></td>
</tr>
<tr>
<td><img src="image7.png" alt="Image 7" /></td>
<td><img src="image8.png" alt="Image 8" /></td>
</tr>
</tbody>
</table>
Use the information from your observations to answer the following questions:

1. Where did the warm water go in relation to the cold water?

2. Which is denser (heavier), the warm water or the cold water? ______________

3. Where does most heating of ocean water take place?

4. Where does most fresh water enter the ocean?

5. Would the water entering the ocean from rivers move above, below, or mix with the ocean water? ______________

   Use the information from your observations to explain your answer.

6. How could the temperature of a current affect the land near it?

CONCLUSION:

Explain how differences in temperature and salinity can cause currents in the ocean.
UNDERWATER CURRENTS

OBJECTIVE: To investigate how density differences can cause currents.

MATERIALS: (for each group)

- clear container (plastic shoe or sweater box or small glass or plastic aquarium)
- 2 styrofoam cups
- 2 paper or plastic cups
- clothespin
- water
- salt
- pencil
- masking tape
- paper towels
- ruler
- dirt or soil
- food coloring
- spoon

PROCEDURE:

1. Use the pencil to punch a hole near the bottom of the styrofoam cups. Make sure that the hole goes all the way through. Then cover the hole in each cup with a strip of masking tape. The tape should come above the top of the cup. See figure A.

   Figure A:

2. Fill the clear container to within one to two inches from the top with warm water.
3. Fill both plastic or paper cups with water. Add a few drops of food coloring to each. In one, mix several spoonfuls of dirt until the water is muddy. In the other add salt, stir, and set it aside to reach room temperature.
4. With the clothespin, attach the styrofoam cup to the clear container. See Figure B

   Figure B

5. Pour the colored muddy water into the styrofoam cup. Allow the water in the clear container to settle, then gently pull the masking tape off the cup.
6. Observe the movement of the colored muddy water. Record your observations in the data table.
7. Using a dotted line, draw a diagram of the movement of the colored muddy water as viewed from the top in the data table.
8. Pour the water out of the plastic container, then refill it with tap water.
9. Attach the other prepared styrofoam cup to the container, allow the water to settle and let it sit for a few minutes to reach room temperature.
10. Pour the colored saltwater into the styrofoam cup.
11. Remove the masking tape and observe the movement of the colored salt water.
12. Record your observations and using a dotted line diagram the movement of the water.

**OBSERVATIONS:**

<table>
<thead>
<tr>
<th>Description of movement of colored muddy water</th>
<th>Diagram of movement of colored muddy water</th>
<th>Description of movement of colored salt water</th>
<th>Diagram of movement of colored salt water</th>
</tr>
</thead>
</table>

1. Which is denser, the colored muddy water or the fresh water?
   - The salt water or the fresh water?

2. What would happen to the water entering the ocean from rivers. (this water contains sediments from inland).

3. How might these sediment laden waters create a current?

4. Evaporation of water near the surface will make ocean water more salty. How might this extra-salty water create a current?

**CONCLUSION:**

Explain how density differences can cause currents in the ocean.
WHY DO TIDES OCCUR 50 MINUTES LATER EACH DAY?

PURPOSE: To investigate why tides occur approximately 50 minutes later each day.

MATERIALS: Tides fact sheet

BACKGROUND INFORMATION: It actually takes the moon 29 days to complete one orbit around the earth. For this activity, so that the math will be easier, we are rounding this time to 30 days.

PROCEDURE: Use the information in the tide fact sheet to answer the following questions.

1. If it takes the moon 30 days to complete one revolution (which is also the time it takes it to complete one rotation) around the earth (360°), how many degrees does it travel in one day (24 hours)?

   Set up the equation like this:

   \[
   \frac{30 \text{ days}}{360°} \times \frac{24 \text{ hours}}{1 \text{ day}} = \text{hours/°}
   \]

   How many degrees would the moon travel in one day? \(\text{°/day}\)

2. It takes the earth 24 hours to complete one rotation (360°). How long does it take the earth to travel the same number of degrees that it takes the moon to travel in one day?

   \[
   \text{ans. to question #1} \times \frac{24 \text{ hours}}{360°} = X \text{ hours}
   \]

   \[
   X \text{ hours} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = \text{minutes to travel the same number of degree as the moon in a day.}
   \]

CONCLUSION: Using the information gained from this math activity, explain why the tides occur approximately 50 minutes later each day.
THE 24-HOUR CLOCK

OBJECTIVES: 1. To be able to express time in 24-hour and 12-hour clock time.
2. To understand time using the 24-hour clock and read time tables.

BACKGROUND INFORMATION:
Time on tide charts and tables is given in four digits and is based on the 24-hour clock, also called military or nautical time. 24-hour clock time is used in navigation, the military, and to prevent confusion in international communications. The 24-hour clock begins with midnight which is 0000 hours (zero hundred hours) and runs through noon which is 1200 hours (twelve hundred hours). 6:33 am is expressed as 0633 hours (zero, six hundred thirty-three hours). 2:15 pm is expressed as 1415 hours (fourteen hundred fifteen hours). 24-hour clock time is always expressed in four digits. The first two digits refer to hours and the last two digits refer to minutes, 0828 is 08 hours and 28 minutes. When computing time differences using the 24-hour clock times, remember that you are working with time and the units are 60 minutes in an hour and 24 hours in a day. You are not dealing with units of 10 or 100 when adding or subtracting time. When adding, if the last two digits are more than 60 you must convert these minutes into the appropriate hours. (60 minutes = 1 hour and 24 hours = 1 day).

PROCEDURE:
1. Study the comparison of the 24-hour clock and the standard clock times.
2. Fill in the chart comparing these times.
3. Calculate time differences using 24-hour clock time.
4. Answer the questions.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Midnight</th>
<th>24-Hour</th>
<th>Noon</th>
<th>24-Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 pm</td>
<td></td>
<td>0000 or 2400</td>
<td>12 am</td>
<td>1200</td>
</tr>
<tr>
<td>3 am</td>
<td></td>
<td>0300</td>
<td>3 pm</td>
<td>1500</td>
</tr>
<tr>
<td>6 am</td>
<td></td>
<td>0600</td>
<td>6:15 pm</td>
<td>1815</td>
</tr>
<tr>
<td>11 am</td>
<td></td>
<td>1100</td>
<td>11 pm</td>
<td>2300</td>
</tr>
</tbody>
</table>
In the chart below change the standard 12-hour times to 24-hour clock time and the 24-hour times to standard:

<table>
<thead>
<tr>
<th>Standard Time</th>
<th>24-hour Clock Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 12:10 pm</td>
<td>a.</td>
</tr>
<tr>
<td>b. 3:30 am</td>
<td>b.</td>
</tr>
<tr>
<td>c. 9:00 pm</td>
<td>c.</td>
</tr>
<tr>
<td>d. 10:15 am</td>
<td>d.</td>
</tr>
<tr>
<td>e. midnight</td>
<td>e.</td>
</tr>
<tr>
<td>f. 0050</td>
<td>f. 0050</td>
</tr>
<tr>
<td>g. 1700</td>
<td>g. 1700</td>
</tr>
<tr>
<td>h. 0207</td>
<td>h. 0207</td>
</tr>
<tr>
<td>i. 2232</td>
<td>i. 2232</td>
</tr>
<tr>
<td>j. 1200</td>
<td>j. 1200</td>
</tr>
</tbody>
</table>

COMPUTING TIME DIFFERENCES USING 24-HOUR TIME:

Sample problems:

\[
\begin{align*}
0340 & \quad 1803 & \quad 1917 \\
+0210 & +0457 & +1030 \\
0550 & 2260 & 2300 \\
\end{align*}
\]

\[
0535 = 1095 \quad (\text{cannot subtract 45 minutes})
\]

\[
0050 = 1095 \quad (\text{cannot subtract 45 minutes})
\]

\[
1352 = 3752 \quad (\text{Must borrow a day = 24 hours})
\]

\[
-0535 \quad -0302 \quad -0745 \quad -0745 \\
2023 \quad 0218 \quad 0253 \quad 2113 \\
+1446 \quad +1453 \quad +0816 \quad +1319 \\
-1031 \quad -0753 \quad -2313
\]

Work the following problems:

\[
\begin{align*}
1233 & \quad 0218 & \quad 0253 & \quad 2113 & \quad 1915 & \quad 0317 & \quad 2313 & \quad 1338 & \quad 2207 \\
+0009 & +1446 & +1453 & +0816 & +1319 & -1706 & -1031 & -0753 & -2313
\end{align*}
\]

Answer the following questions:

1. What do you think would be the advantages of using the 24-hour clock at sea or in scientific investigations?

2. What types of work (jobs) could use the 24-hour clock advantage?
| Time | Time | Time | Time | Time | Time | Time | Time | Time | Time | Time | Time | Time | Time | Time | Time |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

**Times and Heights of High and Low Waters**

*Severn River Entrance, G.A., 1995*

*Times and Heights of High and Low Waters*

*Severn River Entrance, G.A., 1995*
HOW TO READ TIDE TABLES

All predicted tide times and heights are taken from Tide Tables 1995, East Coast Of North and South America, U.S. Dep. of Commerce, NOAA, Distribution Branch, 6501 Lafayette Ave., Riverdale, MD 20737, (301) 436-6990. The information is given for the Savannah River Entrance only. To find the times and heights of tides near Sapelo, you must use the conversion table. All times are given in the 24-hour clock system. Example: 0245 hours is 2:45 am and 2129 hours is 9:29 pm.

NOTE: Beginning on the first Sunday in April and ending on the last Sunday in October, Daylight Savings Time is in effect. You must add one hour to your tide table times during these dates.

Look at your tide table for January, 1995. Find January 20th. In this activity, we will use the feet measurements. You may disregard the centimeter measurements.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Height</th>
<th>Height in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0410</td>
<td>-0.5</td>
<td>-15</td>
</tr>
<tr>
<td>F</td>
<td>1004</td>
<td>7.3</td>
<td>223</td>
</tr>
<tr>
<td></td>
<td>1631</td>
<td>-0.4</td>
<td>-12</td>
</tr>
<tr>
<td></td>
<td>2230</td>
<td>6.7</td>
<td>204</td>
</tr>
</tbody>
</table>

Low tide (low low water)  High tide (high high water)
Low tide (low water)      High tide (high water)

On Friday, January 20, 1995, there was a low tide of -0.5 ft. (.5 feet below mean low tide) at 0410 hours or 4:10 am at the outer bar. A high tide of 7.3 ft. occurred at 1004 hours or 10:04 am. At 1631 hours or 4:31 pm a low tide of .4 below mean low tide occurred. At 2230 hours or 10:30 pm, a high tide of 6.7 ft. above mean low tide occurred.
SAMPLE PROBLEMS

You will use the tide table for the Savannah River Entrance to begin all your problems.

1. Find December 21st on your tide tables. What is the time and height of high high water (the highest of the high tides)?

   \[
   \begin{align*}
   \text{Time} & \quad \text{Height} \\
   \end{align*}
   \]

   (The two high tides for December 21st occur at 0659 hours = 8.6 ft. and at 1916 hours = 7.6 ft. Since 8.6 feet is higher than 7.6 feet, the high high water occurs at 0659 hours and is 8.6 feet above mean low water. Always remember to add the units hours and feet, etc. to your answers)

2. Find the time of the lower low water and the height of the tide at the Savannah River entrance, on March 5th.

   \[
   \begin{align*}
   \text{Time} & \quad \text{Height} \\
   \end{align*}
   \]

   (Find the March table, look for March 5th. The lower low water occurred at 1646 hours and the height is -0.2 feet because -0.2 feet is less than -0.1 feet.)

3. (a) Find the tidal range and time duration between the morning low water and the morning high water at the Savannah River entrance on May 18th.

   \[
   \begin{align*}
   \text{Tidal Range} & \quad \text{Time Duration} \\
   \end{align*}
   \]

   (To find tidal range you must subtract the height of the morning low from the morning high = 7.3 feet - -0.8 feet = 8.1 feet. Remember that when you subtract a negative, you add. To find the time duration, subtract 0451 hours from 1049 hours. Time duration is expressed in hours and minutes so the answer is 5 hours and 58 minutes. To subtract 51 minutes from 49 minutes, you must borrow an hour or 60 minutes)

   \[
   \begin{align*}
   0451 & -0451 \\
   1049 & -09109 \\
   0558 & \\
   \end{align*}
   \]

3. (b) How many feet/hour does the tide ebb?

   (First, you must change 5 hours and 58 minutes into a decimal. 60 divided into 58 is .97. So 5 hours and 58 minutes = 5.97 hours. Next, divide 5.97 hours into 8.1 feet = 1.356 feet/hour. Rounded to the nearest tenth, the answer is 1.4 feet/hour).

D-37
HOW TO USE CONVERSION TABLES PROBLEMS

The conversions listed below are taken from the Tide Tables 1995, East Coast of North and South America, Dept. of Commerce, NOAA.

<table>
<thead>
<tr>
<th>PLACE</th>
<th>POSITIONS</th>
<th>DIFFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Latitude</td>
<td>Longitude</td>
</tr>
<tr>
<td></td>
<td>North</td>
<td>West</td>
</tr>
<tr>
<td>GEORGIA.cont.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Catherines and Sapelo Sounds-cont.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time meridian, 75° W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine Harbor, Sapelo River</td>
<td>31° 33'</td>
<td>81° 22'</td>
</tr>
<tr>
<td>Eagle Creek, Mud River</td>
<td>31° 31'</td>
<td>81° 17'</td>
</tr>
<tr>
<td>Creighton Narrows Entrance, Crescent River</td>
<td>31° 29'</td>
<td>81° 20'</td>
</tr>
<tr>
<td>Mud River, at Old Teakettle Creek</td>
<td>31° 29'</td>
<td>81° 19'</td>
</tr>
<tr>
<td>Doboy and Altamaha Sounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old Tea Kettle Creek (Daymark #173)</td>
<td>31° 26'</td>
<td>81° 18'</td>
</tr>
<tr>
<td>Blackband Creek, Blackband Island</td>
<td>31° 29'</td>
<td>81° 13'</td>
</tr>
<tr>
<td>Old Tower, Sapelo Island</td>
<td>31° 23'</td>
<td>81° 17'</td>
</tr>
<tr>
<td>Hudson Creek entrance</td>
<td>31° 27'</td>
<td>81° 21'</td>
</tr>
<tr>
<td>Thiremis Cut entrance, Danen River</td>
<td>31° 21'</td>
<td>81° 23'</td>
</tr>
<tr>
<td>Danen, Danen River</td>
<td>31° 22'</td>
<td>81° 26'</td>
</tr>
<tr>
<td>Rococoedundy River (Daymark #185)</td>
<td>31° 27'</td>
<td>81° 20'</td>
</tr>
<tr>
<td>Wolf Island, south end</td>
<td>31° 20'</td>
<td>81° 19'</td>
</tr>
<tr>
<td>Channery Island, South Altamaha River</td>
<td>31° 20'</td>
<td>81° 28'</td>
</tr>
<tr>
<td>Hampton River entrance</td>
<td>31° 13'</td>
<td>81° 19'</td>
</tr>
<tr>
<td>Jones Creek entrance, Hampton River</td>
<td>31° 18'</td>
<td>81° 20'</td>
</tr>
<tr>
<td>St. Catherines and Sapelo Sounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walburg Creek entrance</td>
<td>31° 42'</td>
<td>81° 09'</td>
</tr>
<tr>
<td>Kilkenny Club, Kilkenny Creek</td>
<td>31° 47'</td>
<td>81° 12'</td>
</tr>
<tr>
<td>Bear River, (Range &quot;A&quot; Light)</td>
<td>31° 48'</td>
<td>81° 11'</td>
</tr>
<tr>
<td>Bear River Entrance</td>
<td>31° 43'</td>
<td>81° 08'</td>
</tr>
<tr>
<td>Sunbury, Medway River</td>
<td>31° 46'</td>
<td>81° 17'</td>
</tr>
<tr>
<td>Belfast, Bellas River</td>
<td>31° 49'</td>
<td>81° 18'</td>
</tr>
<tr>
<td>North Newport River (Daymark #119)</td>
<td>31° 41'</td>
<td>81° 15'</td>
</tr>
<tr>
<td>North Newport River</td>
<td>31° 40'</td>
<td>81° 16'</td>
</tr>
<tr>
<td>South Newport Cut, N. Newport River</td>
<td>31° 40'</td>
<td>81° 16'</td>
</tr>
<tr>
<td>Eagle Neck, South Newport River</td>
<td>31° 39'</td>
<td>81° 19'</td>
</tr>
<tr>
<td>Thomas Landing, S. Newport River</td>
<td>31° 39'</td>
<td>81° 15'</td>
</tr>
<tr>
<td>South Newport River</td>
<td>31° 38'</td>
<td>81° 16'</td>
</tr>
<tr>
<td>South Creek, Mill Creek (Daymark #193)</td>
<td>31° 34'</td>
<td>81° 11'</td>
</tr>
<tr>
<td>Dallas Bluff, Jullenton River</td>
<td>31° 35'</td>
<td>81° 19'</td>
</tr>
<tr>
<td>Harms Neck, Barbour Island River</td>
<td>31° 37'</td>
<td>81° 16'</td>
</tr>
<tr>
<td>Barbour Island, Barbour Island River</td>
<td>31° 35'</td>
<td>81° 14'</td>
</tr>
<tr>
<td>Blackbeard Island</td>
<td>31° 32'</td>
<td>81° 13'</td>
</tr>
<tr>
<td>Dog Hammock, Sapelo River</td>
<td>31° 32'</td>
<td>81° 16'</td>
</tr>
<tr>
<td>Bellville Point, Sapelo River</td>
<td>31° 32'</td>
<td>81° 22'</td>
</tr>
</tbody>
</table>

Follow the following sample problems to understand how to convert tide times and heights from the Savannah River Entrance readings to the times and heights for areas around Sapelo.

1. Find the time and height of the higher high water of the tide at Old Tower, Sapelo on February 7th. Time Height

(First you must find the time and height of the higher high water at the Savannah River entrance. Time = 0109 hours. Height = 6.2 feet. Then, look at the conversion table and find Old Tower, Sapelo under the Place column. Go across to the time and height differences column and add the time and height to the Savannah River entrance figures. [If there is a - sign, you subtract.] Time: 0109 hours (Savannah River) Height: 6.2 feet (Sav. River)

\[
\begin{align*}
\text{Time:} & \quad +12\text{ minutes (Old Tow. Sapelo)} \\
\text{Height:} & \quad +1.00\text{ feet (Old Tower)}
\end{align*}
\]

0121 hours 7.2 feet
So on February 7th, the highest high tide occurred at 0121 hours and was 7.2 feet.

2. Find the tidal range and time duration between the afternoon low tide and the afternoon high tide at Old Tea Kettle Creek (Daymark # 173) on December 1st.

Tidal Range ___________________________ Time Duration ___________________________

(First find the time and height of both tides at the Savannah River entrance. Afternoon low tide = 2203 hours and 0.0 feet. Afternoon low tide = 1540 hours and 6.9 feet. Next, find the conversion for Old Tea Kettle Creek (Daymark # 173) and add this to the Savannah times and heights. low = + 039 hours and + 0.82 feet, high = + 039 hours and + 0.96 feet.

Afternoon low time: 2203 hours Afternoon low heights: 0.0 feet
+ 039
2242 hours + .82
0.82 feet

Afternoon high time: 1540 hours Afternoon high heights: 6.9 feet
+ 039
1579 = 1619 hours + .96
7.86 feet

1579 = 1619 hours because 79 is larger than 60 and you are dealing with minutes in this problem.

Next subtract the afternoon high tide time and height from the morning low tide time and height.

Time: 2242 hours Height: 7.86 feet
-1619
0623 hours - .82
7.04 feet

Tidal Range = 7.04 feet Time Duration = 6 hours and 23 minutes
TIDE TABLES

PURPOSE: To understand how to read tide tables.

MATERIALS: 1995 Tide Tables
            How to Read Tide Tables
            Sample Problem Sheet
            How to Use Conversion Tables Problems

NOTE: Before attempting this activity, students should understand time using the 24 hour clock and how to add and subtract time. Complete "The 24-Hour Clock" activity before beginning this activity.

PROCEDURE:

1. Read carefully "How To Read Tide Tables and do the "Sample Problems." These are done for you, but do them yourself as you read them.
2. Read and carefully follow the directions on "How To Use Conversion Tables."
3. Remember that when adding or subtracting time, you are using 60 minutes in one hour and 24 hours in one day.
4. Work the Tide Table Problems.

TIDE TABLE PROBLEMS: Do steps 1 and 2 of procedure before attempting these problems.

1. Find the time of the low water (this is the highest of the low waters) and the height of the tide at Meridian dock, which is located on Hudson Creek, on January 11, 1995.
   Time ____________________  Height ____________________

2. Find the time and height of the afternoon high tide at Old Tower, Sapelo on November 20, 1995.
   Time ____________________  Height ____________________

3. Find the time and height of the morning low tide at Blackbeard Creek on June 4, 1995.
   (Remember that June is during Daylight Savings Time).
   Time ____________________  Height ____________________

4. (a) Find the tidal range and time duration between the morning low water and the morning high water at Marsh Landing Dock (use Old Tower, Sapelo times and heights) on December 22, 1995.
    Tidal Range ____________________
    Time Duration ____________________

(b) How many feet/hour does the water flood? ____________________
5. Your school science class is planning a trip to Sapelo to conduct a beach clean-up of Nanny Goat Beach on Monday, May 22, 1995. You will leave the mainland from the Meridian Dock on Hudson Creek on the 9:00 am boat and arrive at Marsh Landing Dock on Sapelo between 9:30 and 9:45 am. You will begin your beach clean-up about 10:30 am. You want to complete your clean-up before high tide. (Remember that you will be using Daylight Savings Time)

(a) What is the position of the tides when you leave Meridan Dock?

(b) What will the approximate height of the tide at Marsh Landing Dock be?

(c) At what time will high tide occur on the beach? (use the Old Tower, Sapelo readings to compute)

(d) How much time will you have to conduct your beach clean-up?

6. You and several friends are camping at the Cabretta Campground. You have brought canoes and plan to go fishing in Blackbeard Creek on Saturday, June 24th. You want to fish at high tide and return to Cabretta before low tide. It will take you one hour to canoe from Cabretta to your fishing location.

(a) What time should you leave Cabretta to start fishing at high tide?

(b) What time should you leave your fishing spot to be back at the campground at low tide? (remember daylight savings time)

CONCLUSION: Explain how knowing how to read tide tables can help you plan your beach activities.
USING TIDE TABLES

OBJECTIVE:  1. The students will construct a graph of tidal information for one month.
2. To investigate tidal range and the occurrence of spring and neap tides.

MATERIALS:
Tides fact sheet
1995 Tide tables
Graph paper
Two colored pencils (different colors)

PROCEDURE:
(Specify whether to use morning or afternoon tide heights.
The example uses morning).

1. Label the vertical axis of your graph *Height in Feet*. Label each line on the vertical axis. The bottom line should be the lowest morning tide height for the month. (For December, 1995 it should be -1.4 feet) The top line should be the highest morning tide for the month. (For December, 1995, it should be 8.8 feet).

2. Label the horizontal axis of your graph *Month/Date*. Starting at the left, label each space from 1 to the number of days in the month you are graphing.

3. Make a key to indicate which color indicates morning low tide heights and which indicate morning high tide heights.

4. Using the color for morning tide heights, graph the information given for morning low tide heights. See the example to the right.

5. Using the color for high tide heights, graph the information given for morning high tide heights. See example.

6. Use your graph and the tide fact sheet to answer the questions listed under observations.
OBSERVATIONS:

1. What is the maximum tidal range for the month of __________.
   (This is the greatest difference in feet between a high tide mark and a low tide mark).

2. On which date(s) did this occur? _______________

3. Place an "A" above the bar(s) on your graph for this/these date(s).

4. On which dates did the "Spring Tides" occur for this month? _______________

5. On which of these dates do you think the earth, moon, and sun were in this position? ______
   Why?

6. Put a "B" above the bar(s) for the date in question #5.

7. What is the minimum tidal range for the month of __________.

8. On which date(s) did this minimum tidal range occur? _______________

9. Put a "C" above the bar for the date(s) in question #8.

10. On which dates did the "Neap Tides" occur? _______________

11. In the space below, draw the positions of the earth, moon, and sun for one neap tide.

12. Put a "D" over the bars for neap tide date(s).

CONCLUSION: In a short paragraph define a tide is and explain its causes. Describe tidal range and how knowing the tidal range can help one determine when spring and neap tides will occur. What are spring and neap tides and how often do they occur? Why do they occur when they do? (Explain the position of the sun, moon, and earth).
MAN'S INFLUENCE ON OUR BARRIER ISLANDS

SECTION-E
MAN'S INFLUENCE ON OUR BARRIER ISLANDS

Man has had an influence on Georgia's coast for centuries. More and more people are coming to the coast to enjoy relaxation and recreation along its shores. Many of man's actions along the coast have resulted in undesirable ecological disturbances that either could have been avoided or minimized by proper planning and education.

GROUNDWATER CONTAMINATION:

The major source of fresh water for coastal Georgia is groundwater. Groundwater is brought to the surface by drilling wells into a water-yielding rock called an aquifer. Because of increased population in coastal areas and heavy industrial use of water, groundwater aquifers are becoming contaminated by salt water.

POLLLUTION:

Aquatic pollution is very serious in our marsh-estuarine system. Once pollutants enter the estuary they are often trapped there by tidal currents instead of reaching the open ocean where their effects would be less. These pollutants move back and forth within the estuary. Most pollutants entering the marsh-estuarine system come from industrial wastes, sewage, and pesticides from the runoff of agricultural and forest lands and from cities and towns along the rivers that enter our estuaries. Point source pollution is pollution that comes from industries, water treatment plants, etc. and their source is easy to identify and regulate or control. Nonpoint source pollution or "people pollution" is very difficult to identify and regulate (see the Watersheds and their Importance fact sheet for more examples of nonpoint source pollution. It is important to remember that even a small amount of pollution can travel a long way in the ocean when picked up by currents.

Although industries contribute significantly to the economy of coastal areas, the large volumes of pollutants they create pose severe threats to the productivity and stability of the important estuarine communities. Many of the industrial wastes such as acids, dyes, oil and heavy metals (mercury, lead, zinc, etc.) are not biodegradable and may remain in the estuarine system for a long time. These industrial pollutants are consumed by oysters, crabs and fish making them unfit for human consumption.

Sewage from homes near the rivers and marshes often is not treated before entering the marsh-estuary system. This raw sewage becomes food for many shellfish which are filter or deposit feeders. This untreated sewage doesn't directly affect the shellfish but often is toxic to man.

Pesticides mostly enter the system by way of runoff from agricultural and forest lands. Detritus
feeders and bottom dwelling organisms concentrate these pesticides and their effects are
magnified as they pass through the food chain. The decline in bald eagle, brown pelican and
osprey populations along our coast are thought to be mostly due to DDT pollution.
All of us pour or flush chemicals down the drain or onto our lawns almost daily (washing
powders, dish detergent, toilet paper, bleach, paint thinners, cleaning products and oil from our
cars). These will eventually reach the water table and someday reach the ocean.

**DAMMING RIVERS:**

The damming of rivers is important for the production of electricity, but it also traps sand that
would otherwise have reached our beaches. This "sand starvation," as it is called, is partly
responsible for the recent acceleration in beach erosion along Georgia's coast and elsewhere.

**DREDGING:**

Dredging is important for the maintenance of harbors, inland waterways, and for material for
highway construction. Dredging destroys portions of the marshes, interrupts the natural flow of
water and sand between the islands and increases erosion and deposition. It also increases the
amount of silt and the turbidity in the water, which affects the amount of photosynthesis carried
on by phytoplankton. Sessile and bottom dwelling organisms, such as oysters and clams, may be
buried by the silt. Since dredge spoil (material dredged up from the ocean bottom) is usually very
acidic, the marshes where it is deposited are often unproductive for many years and often create
breeding grounds for mosquitoes. On the positive side, spoil deposits create nesting and feeding
areas for many migratory birds.

**CAUSEWAYS AND HIGHWAYS:**

Improperly planned causeways and highways across marshlands often obstruct tidal flow and may
cause the loss of extensive areas of marsh habitat. Unrestricted tidal flow is necessary for the
removal of sediments, the transportation of nutrients and detritus to the estuaries, and the
maintenance of spartina (marsh grass) communities.

**LITTER:**

Trash in the ocean and on our beaches has only recently gained recognition as an international
problem. Worldwide, over 100,000 freighters, tankers, naval ships, commercial fishing boats and
cruise ships dump more than 6 million tons of trash per year into the ocean. Weekend boaters in
the United States discard more than 34,000 tons of trash into the ocean per year.
Many of us, without thinking, leave styrofoam, aluminum cans, baggies, etc. on the beaches.
Millions of marine animals such as dolphins, whales, sea birds, fishes and sea turtles die each year
from entanglement in or by ingesting this debris. This trash also poses a problem to shrimpers and
boaters by causing damage to boats requiring expensive repairs and loss of profit.
GROINS, JETTIES AND SEAWALLS:

To prevent beach erosion, groins and jetties are often built out into the ocean to trap sand. Rather than preventing erosion as they were intended, they often increase the erosion. These structures interfere with the littoral drift of sand caused by longshore currents. The updrift sides of these groins and jetties do capture sand but the downdrift sides lose sand more rapidly than normal as the longshore current continues to move southward. Seawalls built to protect beachfront property actually accelerate the erosion they were meant to prevent. When waves roll onto a beach, the water spreads out over the sand and the energy of the wave is dissipated over a large area. When a seawall is added, the energy of the wave has nowhere to go and strikes the wall with full force, creating a severe backwash that undermines whatever beach remains and carries it away.

DRAINING OF WETLANDS:

Today about one-half of the population of the United States lives in coastal areas. At one time there were more 200 million acres of wetlands in the United States. Today fewer than 100 million acres remain. Man, not realizing the importance of wetlands as flood reducers, nurseries, natural filters, and natural water storage areas, has drained and filled wetlands for farmland and to build homes and industries.

DESTRUCTION OF SAND DUNES:

Not realizing the importance of sand dunes as buffers against storms and as sand reserves for beaches, man has bulldozed many sand dunes in order to obtain a better view of the ocean from homes, and in order to build hotels and condominiums near the water. We also ride off-road vehicles and walk over the dunes, not realizing the fragile nature of dune plants. Man also, for years, picked the beautiful sea oats to make flower arrangements. Sea oats and dune plants play a vital role in capturing and keeping sand on the dunes and therefore the beaches. Dunes are important in reducing the impact of storm winds and waves and therefore are essential to the reduction of beach erosion. Today it is illegal to pick sea oats and if caught one faces a $500 fine.

ACID RAIN:

Water in the atmosphere, including fog, rain, sleet, and snow, may become polluted by dirty air. Exhaust from cars and factories that burn fossil fuels contains gases that become dangerous when mixed with water. When acid rain falls on lakes, ponds, sloughs or in the ocean it can change the chemical makeup of the water and affect the health of the organisms living there.

OIL LEAKS AND SPILLS:

As of 1995, Georgia, luckily, has not experienced any major oil spills. The potential for leaks or spills is an ever present threat due to the heavy use of the Savannah River, the Brunswick Harbor and the naval base at St. Mary's.
Oil is lighter than water and will float. It acts like a blanket over the water and can affect wildlife for miles. Birds are especially vulnerable and, if coated with oil, are unable to swim or fly. When oil washes onto the beach it suffocates all the organisms living there. The oil will eventually sink to the bottom of the ocean and when it does, it kills the creatures that live there as well. The marsh-estuarine system is one of our most valuable natural resources. It not only performs important ecological functions but it is important to man in many ways such as: commercial harvest of fish, shellfish and wildlife; research and education; many forms of outdoor recreation like fishing, hunting, nature study, boating, swimming, etc. Only through education and understanding can man's undesirable influences, whether intentional or accidental, be corrected.

WHAT CAN YOU DO?

The responsibility for the care and health of our marine environment belongs to us all. We can have a positive impact on the marine environmental conditions and the legislation that controls its use.

All of us can help by doing simple things such as:

- Consider using alternatives to disposable plastic products, such as reusable dinnerware, containers, paper bags and cups and washable diapers.

- Take a trash bag with you every time you go to the beach or boating and take all your trash home with you.

- If you buy six-pack drinks attached together with plastic rings, cut the rings into small sections that are too small for animals to become entangled in.

- Try to re-use shopping bags.

- Be careful not to walk on fragile dune plants, and remind others to do the same.

- Adopt a beach, stream, lake, pond, or river and organize individual or group clean ups. Take pictures and write an article for your local paper.

- Investigate to see if factories near you have the proper filtering devices to clean the air and water they put into the environment.

- Try walking or riding a bike or carpooling and use your car less.

- Buy only phosphate-free detergents and use less than the label says.
- Buy toilet paper that has not been bleached (chlorine and dyes do not biodegrade and remain in the water).

- Look around your county and neighborhoods. Are there industries or factories that are polluting the environment? If so, contact your local legislators and encourage them to look into the problem.

- Write to cruiselines and local shrimping companies and encourage them to be more environmentally conscious and to deposit their trash on land rather than at sea.

- We can become more aware of current legislation that affects our coasts and write to our legislators and encourage them to vote for the protection of our coastal areas. Do not be afraid to voice your concerns. Write letters to the president, the governor, and your local and state legislators. When writing to legislators or companies, remember to be clear and polite and to (1) voice your concern (2) give factual evidence to support your concern and (3) offer suggestions of ways that your concern might be addressed. Include your return address for an answer. The more letters politicians receive, the more attention they will pay to a particular issue. It is generally accepted that for every letter received, there are at least 100 others with the same concern.

President of the United States
The White House
Washington, D.C. 20501

The Honorable _________
U.S. House of Representatives
Washington, D.C. 20515

Office of the Governor
203 State Capital Building
Atlanta, Ga. 30334

(Call your local court house for local addresses. Call the office of the Secretary of the Senate (404) 656-5042 and ask for your senators address or ask for a "white book," which has all the addresses of State Legislators.

-Become vocally supportive of the preservation of our wetland areas.

-Most of all, set a good example for others.
PERMEABILITY AND POROSITY OF SOIL

Permeability is the capacity of rock or soil to transmit water. It is a measure of the relative ease with which water will flow through the rock or soil. Porosity is a measure of the rock or soil's ability to hold water and is expressed as a percentage. A rock or soil that holds a lot of water is said to be porous and is permeable if it allows water to flow easily through it. A rock or soil is impermeable when it does not allow water to flow through. When all the open spaces between the soil particles or rock particles become filled with water, the soil is said to be saturated. The water table flows along the zone of saturation. Above the zone of saturation (the water table) is the zone of aeration or unsaturated zone. In this zone of aeration, the spaces between the soil grains is partly filled with water and partly with air. It is from this zone of aeration that plant roots get their water. Most plants will drown if their roots are completely covered with water. Marsh plants are the exception, they have adapted to living in a water environment.

When water from rain or run-off flows over the surface of the earth, it will seep into the ground and travel downward until it reaches the water table. This water then flows downslope or downhill, relatively slowly, through underground permeable rock and eventually to the ocean. How fast the water in the water table flows depends on the slope of the land and the permeability of the rock or soil through which it is flowing. Water flows faster down a steep slope. The amount of space between the soil particles also has an effect on the speed of flow of the groundwater. Water flows faster through gravel and sand than through silt and clay. In regions like coastal Georgia and on islands such as Sapelo, where the topography is relatively flat, the water table would flow very slowly (even through highly permeable rock or soil). Therefore, any pollutants that reach the flat coastal regions of the state will tend to stay in the water table.

<table>
<thead>
<tr>
<th>Sediment</th>
<th>Porosity %</th>
<th>Permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>gravel</td>
<td>25 - 40</td>
<td>excellent</td>
</tr>
<tr>
<td>sand</td>
<td>30 - 50</td>
<td>good to excellent</td>
</tr>
<tr>
<td>silt</td>
<td>35 - 50</td>
<td>moderate</td>
</tr>
<tr>
<td>clay</td>
<td>10 - 20</td>
<td>poor (impermeable)</td>
</tr>
</tbody>
</table>

Soil and rock can filter some pollutants out of groundwater before it reaches the ocean. This filtering ability depends on the permeability and mineral composition of the soil. Sand is not a good filter of pollutants because the water travels through it too fast. Clay and silt, however, are better filters to pollutants because water does not travel through them as fast. Because clay, the major component of marsh mud, is almost impermeable to water, marshes serve as a good filter to pollutants by trapping them in the marsh mud where they can be decomposed by bacteria. There is a limit, however, to the amount of pollutants a marsh or any soil can filter. Therefore it is important first of all to prevent pollutants from reaching our water table and secondly to preserve our marshes so they can naturally filter the pollutants from the water before they reach the ocean.

Each habitat on a barrier island such as Sapelo has a different type of soil, each having its own characteristic porosity and permeability. It is interesting to test the porosity and permeability of the various habitats as you travel through them.
WATERSHEDS AND THEIR IMPORTANCE

A watershed (total drainage basin) is defined by topography or the shape of the land that governs the path runoff follows as it moves from higher to lower elevations. The watershed includes not only the streams and rivers that flow directly into an ocean, but also wetlands and dry land areas over which the runoff flows. In other words, a watershed is like a large bowl. All the water that falls into that bowl eventually ends up at the bottom (the ocean). Everyone lives within a watershed and every watershed eventually drains into the ocean. Through the water cycle (evaporation, transpiration, condensation and precipitation), our homes and businesses are all connected to local watersheds. The water in these small local watersheds eventually reaches the ocean. Therefore, we all have an effect on our region's water quality and thus on the quality of the water that reaches our oceans.

Development of land within a watershed can have severe consequences on water quality. Sources of pollution may be "point source" pollution which is easy to identify, like waste water treatment plants. Once identified, the sources of point source pollution can be regulated and to some extent controlled. "Nonpoint source" pollution or "people pollution" is much more difficult to pinpoint because it consists of pollutants that come from everyday activities such as driving our cars (exhaust), fertilizing the lawn, walking pets, changing oil in a car and littering. Nonpoint source pollution collects over large areas and is washed from streets and lawns into streams that eventually lead to the ocean. This nonpoint source pollution increases due to development because roads, driveways, parking lots that are all made of impervious surfaces do not allow the infiltration of stormwater into the soil. These paved surfaces increase the amount of runoff which can pick up pollution and they are often responsible for increased erosion and flooding. The amount of poisonous runoff from oil on our streets alone amounts to the same as a major oil spill.
In undeveloped or natural areas, runoff is not usually a problem. Grass, trees, and other vegetation slow runoff and reduce erosion by allowing the water to seep into the ground where it replenishes the groundwater supply. They allow the natural filtering of pollutants by the soil. The quality of water in our watersheds is important because all life along a food chain is ultimately dependent on its water environment. Many microscopic plants and animals (plankton) and other small water organisms serve as food sources for small fish. These small fish are food for larger fish. They, in turn, feed birds and other animals including man. Worms, plants, and microscopic organisms living in sediments (infauna) or on sediments (epifauna) at the bottom of a waterway or the ocean are also an important part of the food chain. They are also food for fish and shellfish which in turn are eaten by larger fish, wildlife and man. At each link in the food chain, the concentration of pollutants may increase. A pollutant level in the sediment that does not harm worms, snails or fish may accumulate in the food chain and become harmful to the higher organisms that eat them.

Sapelo is very unique and fortunate in one sense because its immediate watershed, the Duplin River Watershed, has no rivers entering directly into it. The water that enters directly into the Duplin River comes from rainfall or runoff from the marsh. The water in the Duplin River, having no freshwater flow, is washed back and forth with the tides, much of it staying in the river. If pollutants enter the Duplin River, they have a tendency to stay there. The quality of water around Sapelo is also influenced by the water from the Sapelo, Mud and South Newport Rivers to the north and the creeks and rivers that enter Doboy Sound to the south. These creeks and rivers are much more susceptible to the pollutants from runoff from the mainland and in turn have an effect on the quality of the water around Sapelo. Since all the islands along the Georgia coast and even the Atlantic coast are connected by the ocean, any pollutant entering any part of the system could eventually have an effect on the quality of water and therefore the quality of life on Sapelo.

Each of us, whether we know it or not, contribute to nonpoint source pollution that eventually reaches our oceans. We can help stop or at least reduce this pollution by doing such things as:

-Avoid overuse of fertilizers and pesticides. Use natural alternatives where possible.
-Check for and repair leaks in toilets and faucets.
-Compost solid food wastes.
-Determine what household products contain toxins and use non-toxic alternatives.
-Drive less and keep your car tuned up to reduce poisonous emissions.
-Mulch around plants to reduce evaporation.
-Place all litter in appropriate containers.
-Plant bare areas with vegetation.
-Plant disease and pest resistant plants.
-Pick up after your pets and dispose of the wastes in the garbage or toilet.
-Recycle.
-Recycle used automotive fluids.
-Take showers instead of baths.
-Use a mulching lawnmower or set the blade at least two and one-half inches high.
-Use sand instead of salt to de-ice roads.
-Wash dishes in a dishpan rather than under running water or a dishwasher.
-Wash cars on the grass using non-phosphate detergents or at commercial car washes that recycle water.
WATERSHEDS AFFECTING THE WATERS OF SAPELO

OBJECTIVE: To investigate the watersheds affecting the quality of the waters around Sapelo.

MATERIALS: Fact Sheet: Watersheds and Their Importance
Maps: Counties of Georgia
Rivers of Georgia
A Georgia Road Map
Ink pens: red, black, blue
Colored pencils: orange, green, yellow
Pencil
Tracing paper

PROCEDURE:

1. Read the fact sheet: Watersheds and Their Importance.
2. Using a black ink pen and a sheet of tracing paper, trace the outline of the State from the Rivers of Georgia map.
3. Using a blue ink pen, trace and label the rivers that enter into the Atlantic Ocean.
4. Using a Georgia Road map and a pencil, add the following major cities to your traced drawing: Atlanta, Athens, Augusta, Macon, Savannah, Darien, Brunswick.
5. Using a red ink pen, add the location of the city or town nearest to where you live.
6. Answer the following questions.

OBSERVATIONS:

Note: The total watershed of Sapelo consists of all the streams and rivers entering the Atlantic Ocean because longshore currents transport water southward and the Gulf Stream transports water northward.

1. Lay your traced map over the map of the Counties of Georgia (be sure to line up the outline of the State). List the counties in Georgia that could have an effect on Sapelo's total watershed.

2. Using the information from the Watersheds and Their Importance Fact Sheet, shade Sapelo's immediate watershed in green.
3. Using a Georgia road map, list any towns or cities that could have an effect on Sapelo's immediate watershed.
4. Water that enters the ocean from the north of Sapelo can have an effect on the waters around Sapelo because longshore currents transport these waters southward. Using a yellow colored pencil, shade the portion of the State that could affect the waters of Sapelo from the north.
5. Water that enters the Atlantic Ocean from the south of Sapelo could have an effect on the waters around Sapelo because the Gulf Stream could transports these waters northward.
Using an orange colored pencil, shade the portion of the State that could affect the waters of Sapelo from the south.

6. According to the total shaded area on your map (include all colors), estimate the approximate percentage of the state of Georgia that could affect the waters entering the Atlantic Ocean and therefore the waters around Sapelo. __________________________.

7. Could activities that take place in the city or town that you live in or near have an effect on the waters around Sapelo? _______ Explain your answer. __________________________

8. List some of the activities that you yourself take part in that could add non-point source pollution that could affect Sapelo's total watershed. __________________________

9. List some alternatives or ways that you personally could help to reduce the non-point source pollution of Sapelo's total watershed. __________________________

10. Joe Citizen lives on a farm in northeast Tattnall County. He raises horses, cows, and pigs. He also raises cotton. Could he have an effect on Sapelo's total watershed? _______. Explain how. __________________________ Would this be considered point source or non-point source pollution? __________________________ Describe the route that this pollution would take in order to reach the waters around Sapelo.

11. A leak has been detected in a cooling water tank at the Savannah River Nuclear Power Plant near Augusta. What River could this nuclear pollution contaminate? __________________________ Would this be point source or non-point source pollution? __________________________ Could this nuclear pollution reach Sapelo? ___________ Explain how: __________________________

12. Sally Citizen lives in Cresent, Ga. (Find Cresent on your Georgia road map). She does not know it, but the pipe leading to her septic tank has broken and raw sewage is seeping into the ground. If this sewage gets into the water table, would it be point source or non-point source pollution? __________________________ Since there are no rivers or streams entering Sapelo's immediate watershed, could this pollution possibly affect the waters around Sapelo? _______ Explain your answer. __________________________

13. If pollution of any kind reaches the waters around Sapelo, what effect would or could it have on plant and animal life in and around the island? __________________________ How could this affect you? __________________________

CONCLUSION:

In your own words define a watershed, point source and non-point source pollution. Explain how industry and the everyday activities of the citizens of Georgia could affect the quality of life of the plants and animals on or in the waters around Sapelo and ultimately you.
SAPELO'S WATERSHEDS

- Savannah
- Ogeechee
- Sapelo Sound
- Altamaha
- Satilla - St. Marys
SHIPWRECK

PURPOSE: To determine a strategy or strategies for containment and clean-up of oil, wreckage, and other pollutants from a shipwreck.

SCENARIO:

One night in a heavy fog, an oil tanker bound from Savannah to Brunswick collided with a shrimp boat in the intercoastal waterway in Sapelo Sound north of Sapelo Island. Both ships sank. Luckily the men on board both ships were rescued by the Coast Guard. As a result of the collision, an oil spill and other wreckage are headed toward Sapelo. You have been assigned to a clean-up team to try and prevent the oil and wreckage from reaching the estuaries of Sapelo. If the wreckage reaches the estuaries, you must plan what you will do to help clean-up the estuary and to help the organisms that are affected. Before beginning your task, you must meet with the other members of your team and plan your containment and clean-up strategies. Keep in mind that the waters within Sapelo Sound are affected by waves, tides and currents.

MATERIALS

FOR SAPELO SOUND MODEL:

Large plastic container (large storage boxes can be obtained from local department stores)
Sand (from building supply store)
Motor oil
Transmission fluid
Antifreeze
Small pieces of paper, sticks, toothpicks, cloth, plastic, metal
Mixture of red jell-O and water
Hair dryer and stand (stand optional)
Small shells, bird and or animal models, blades of grass, sticks, etc. (these represent the organisms living in the estuary)
Map of Sapelo Sound
Small pebbles or rocks

FOR CONTAINMENT AND CLEAN-UP:

Pieces of sponge
Wire screen
Paper towels
Eyedropper
Plastic spoon
Netting (bags that onions or oranges come in will work)
Pieces of cloth (cheese cloth)
Dish detergent
Large beaker or mayonnaise jar to place pollutants in after they are recovered
PROCEDURE:

1. Divide the class into groups. Give each group the materials listed above.
2. Using the map of Sapelo Sound as a guide, each group should create their Sapelo Sound model. At one end of the container shape the sand to represent the northern end on Sapelo Island. Slope the sand so that some will be underwater. Add sticks and blades of grass to represent the marsh grasses in the estuary. Also place some small pebbles or rocks in the bottom to represent organisms that live in the bottom of the sound. Cover these with a layer of sand. Carefully pour water into the container. You may need to reshape your model after the water is added. At the end of the container where the wind would be coming from the ocean, set the hair dryer in a stand so that it will blow onto the water when turned on. If you do not have a stand for the dryer, assign a student in each group to hold the dryer. Do not turn the dryer on until the oil spill and wreckage has been added to the water.

3. Arrange shells, animals and bird models, blades of grass and sticks, etc. (the grass and sticks represent the plant life) along the edge of the water.
4. Each group should read the shipwreck scenario and discuss what must be done to prevent the oil spill and wreckage from reaching the shore. They should also discuss what they will do if some of the oil does reach shore. Since the shipwreck occurred in the sound, they should also discuss what, if anything, can be done for the organisms living in the water or in the mud on the floor of the sound. They should discuss how the changing tides will affect their clean-up efforts.
5. After each group has planned their strategies, mix all the materials for the oil spill and wreckage from the sunken ships and add this to center of the sound away from the island.
6. Turn on the dryer and allow it to blow onto the water containing the wreckage for a few minutes.
7. Begin your containment and clean-up procedures. Do the best you can in the time you have allotted.

OBSERVATIONS:

1. Were you able to prevent all of the oil and wreckage from reaching Sapelo? Explain your answer.
2. Which items were the easiest to contain or clean-up? How did you accomplish this?

3. Which items were more difficult to contain or clean-up? What did you use to accomplish this?

4. Which items were you unable to contain before they reached the shore of your Sapelo model?

5. Why do you think you were unable to contain the items listed in question #4?

6. Describe what happened to the animals and plants that were on the shore when the spill and wreckage reached them?

7. Were you able to clean the oil and other pollutants from these animals? Explain your procedures.

8. Describe what happened to the organisms that live on the bottom of the sound. Were you able to clean the pollutants from these organisms? Explain why or why not and state what affect you think this will have on them.

9. Leave your model set up overnight and if possible allow the hair dryer to continue to blow (As the wind would do. You might even want to change the direction of the wind). Describe the effect of the oil spill and wreckage on your model overnight.

10. If you can see through your container, observe it from the side. Has any of the oil, antifreeze, transmission fluid, jell-o mixture, etc. soaked into the sand? How deep into the sand did the pollution seep?

11. Many organisms live beneath the sand and mud of the estuary. How would they be affected by the oil spill and wreckage?

12. Would the spill be confined to the estuarine area of Sapelo or would it also affect the beaches on the ocean side of the island and/or the marshes on the mainland? Explain your answer.

CONCLUSION: Describe how an oil spill or major ship wreck would affect the estuaries and coastline of Sapelo. Explain how much of the spill was able to be contained before it reached Sapelo compared to the amount that reached the island. Also describe the effect of the spill on the living organisms in the estuary and marsh and along the beach.
DEVELOP AN ISLAND

SCENARIO:

It is the year 2050 and after several years of major storms and severe erosion to Georgia's coastline, a new island named "Paradise Island" has formed. The island is two and one-half miles long and one and one-half miles wide. On its east shore are sandy beaches and large primary dunes. On its west shore is an immature salt marsh. The center of the island is covered with pines, Wax myrtle, Bayberry, Spanish Bayonet, Cabbage and Saw Palmettos and numerous vines. There are only a few very young live oaks. The water depth between Sapelo and this new island is only about 10 to 15 feet deep. However, just to the north of Little Sapelo is a shipping channel that is 40 feet deep. The island is located twelve miles east of Sapelo and five miles northwest of Grays Reef. With the destruction of Florida's Coral Reefs, Grays Reef is now very commercially important for sports fishing and scuba diving. It is also the site of an underwater research facility for the University of Georgia.

The island has been purchased by a large company and you have been hired to develop immediate and long-range plans for the development of the island. The owners are very environmentally conscious. You have been told that the island must be developed in such a way as to earn the owners a profit on their investment but at the same time preserve the integrity of the island ecosystems. The owners want to attract tourist and scuba divers from all over the world. They also hope to attract the family of the UGA personnel working in the underwater research facility at Grays Reef and other research professors. They want teachers from all over the southeast to be able to bring small groups of students for 3 to 5 day study experiences. Everything that you plan must be ecologically correct. No pollutants or chemicals can ever be added to the island or the ocean that might harm the coral reef, since it is one of the major attractions for tourists.

You are to present your plan for the island's development to the company's board of directors. Your plan is to include immediate plans, plans for five years from now, 10 years from now with final completion in 20 years. You must submit a written plan for the island for each time period that includes everything that people will need: entertainment, shopping, education, food, water, electricity, transportation (to and from the island as well as on the island), and waste management. You must also submit 4 sketches or drawings of the island. One representing what immediate use of the island will be, one showing the five-year plan, one for the 10-year plan and one for the 20-year plan. There must be a marina with a dive shop and a dock for supply ships, dive boats, deep-sea fishing and sightseeing boats. Remember that in no way can you harm the environment or the ecology of the nearby limestone reef or the island ecosystems.

E-18
BARRIER ISLAND HABITATS

SECTION-F
THE ESTUARY

Estuaries are unique and important ecosystems that form between the mainland and barrier islands where freshwater is mixed with salty water of the ocean. Each estuary is different and its identity is determined by the surrounding geography and climate and the amount of fresh water entering the estuary. All estuaries have formed as the result of the melting of continental glaciers that has caused sea level to rise and flood the mouths of rivers. The habitats that may be included in the estuary are the salt marsh, mud (tidal) flats, sounds and tidal creeks. These fragile, tidally influenced environments include the most biologically productive ecosystems in all of nature.

Estuaries are rich because they are great absorbers and trap nutrients that flow into them. Rainwater picks up dissolved minerals (carbon, nitrogen, and phosphorus, etc.), chemicals and materials from the land and this material eventually enters the estuary. Once in the estuary, it is mixed with salt water, carbon dioxide, marsh grasses, algae, phytoplankton and dead and decaying plant and animal matter (detritus) and trapped in the estuary by the ebbing and flooding tides. This constant mixing of nutrients from both the land and the ocean, creates a murky brown mixture of fresh and salt water and nutrients (liquid plant food) that makes the estuarine waters so productive.

Conditions within the estuary are erratic. The salinity varies with the amount of freshwater influx and may range from 0 - 35 ppt (parts per thousand). The salinity can change from day to day with each tidal cycle, week to week or seasonally. Estuaries also experience wide ranges of rapid changes in temperatures (0º to 100º F.) and water level. The temperature of the water also determines the amount of dissolved oxygen. Warmer water holds less dissolved oxygen than
cooler water. The plants and animals that live in the estuary must be able to adapt to its ever changing conditions.

Despite these harsh conditions, estuaries remain one of the most biologically productive systems on earth. Seventy to ninety percent of recreational and commercially valuable fish, shrimp, crabs, and shellfish depend on and live in estuaries during at least part of their life cycles. The shallow estuarine waters provide spawning grounds for fish and excellent feeding and hiding places for young organisms. Because so many organisms spend their young lives there, estuaries are known as the "nurseries" for the sea. The estuaries also provide breeding and nesting grounds for numerous coastal birds, reptiles and mammals, many of which are endangered.

Many commercial, industrial and recreational activities in the estuary are vital to the economy of Georgia and the nation. Georgia receives $3.5 billion annually directly or indirectly from coastal shipping ports. Each year, Georgia shrimpers catch 4 million pounds of white shrimp, totaling $16 million and 17 million pounds of fish and shellfish, totaling $25 million. By the time these shrimp, fish, and shellfish reach the consumer, $65 million has been added to the economy of Georgia by fisheries. Recreation fishing adds $150 to $200 million to the economy. The sale of boats and sports fishing brings in another $720 million and another $52 million is added from the sale of equipment. In fact, 31% of the Gross National Product of the United States comes from the coast. All of this economy is dependent on a healthy coastal environment.

Estuaries are not only important as nurseries, feeding and nesting grounds and for economics, but also act as natural filters for pollutants, buffers against storms and for their recreational and aesthetic value. People visit estuaries to enjoy water sports, swim, fish, boat, birdwatch and to enjoy their natural beauty.

Sapelo is separated from the mainland by four and one-half miles of salt marsh, estuarine and tidal creek systems. Sapelo was the second estuarine system to be added to the National Estuarine Sanctuary System (December 1976) and is protected by state and federal laws. Sapelo's estuary, the Duplin River Estuary, lies between Sapelo and the mainland and covers 33,000 acres in McIntosh County. The Duplin River Estuary is unique in that it has no major freshwater rivers flowing into it. All the fresh water enters the Duplin River through rainfall and runoff from the marsh and mainland. Because of the lack of freshwater inflow and the daily tidal cycle, Sapelo's estuary is very well mixed with salinities fairly consistent throughout. It is also very susceptible to pollution because the pollutants tend to stay there rather than being flushed by the inflow of fresh water.

Some analysts estimate that 80% to 90% of the population of the United States will live within 50 miles of the coast in the next 20 years. This coastal boom is good for the state's economy, but the building of housing, roads, bridges, motels, new industry and business stresses the estuaries by increasing the types and amounts of pollution entering them. Like any other resource, an estuary can be exhausted by too many demands. Estuaries are too valuable to be mistreated and neglected. It is everyone's responsibility to make intelligent decisions to ensure their preservation.
THE SOUND

The sound is the deeper portion of the estuary located between the mud flats and marshes of the mainland and barrier island. The temperature and salinity of the sound varies with the amount of fresh water entering from rivers or rainfall and from mixing with salt water during incoming tides. An increase in rainfall will quickly decrease the salinity and most times the temperature of the water. The substrate or soil type at the bottom of the sound is a direct result of the deposition of mud and sand from the freshwater streams of the drainage basin that empties into the sound. The grain and particle size of this bottom substrate determine the type, distribution and abundance of the organisms that live there.

Common plants found in the sound are marsh grasses, phytoplankton, algae and sea lettuce (*Ulva*, an attached green algae). A wide variety of zooplankton, which are microscopic animals, live in the upper layers of the sound. Most animals of the sound have made special adaptations to catch their food. Grazing snails crawl along rocks and pilings eating the algae collected there.

Carnivorous snails like the oyster drill and moon snail have a special adaptation, called a radula which is a sandpaper-like tongue used to drill holes in the shells of oysters, clams and other mollusks. Blue crabs use their strong claws to crack shells and catch worms and fish. The starfish uses its tubed feet to open the halves of clams. Sand dollars and sea cucumbers hunt around in the sand for detritus while filter-feeders like worms, clams, scallops, barnacles and sea squirts filter their food out of the water. Sea anemones, soft corals and some fish grab their food from the water as it flows past their tentacles. Fish eat other fish, crustaceans, mollusks, worms and anything else they can catch. Shrimp, hermit crabs and blue crabs are the scavengers of the sound. They hunt along the bottom eating detritus and other dead material they find.

Doboy sound separates Sapelo from the mainland and the islands to the south. Sapelo is separated from the islands to the north by Sapelo sound.
ESTUARY LAB

OBJECTIVE: To investigate what happens when fresh and salt water meet in an estuary.

MATERIALS: Estuary Fact Sheet 4 clear plastic cups
    food coloring salt
    spoon colored pencil (color of food coloring)
    water

PROCEDURE:

1. Read the Estuary Fact Sheet.
2. Fill the four clear plastic cups one-half full of tap water.
3. Place 2 teaspoons of salt in two cups and stir.
4. Place several drops of food coloring into one cup of salt water and one cup of fresh water.

5. Carefully pour a teaspoon of colored salt water into the clear fresh water cup. Observe what happens.
6. Carefully pour a teaspoon of colored fresh water into the cup of clear salt water. Observe what happens.
7. Use the spoon and stir the cups that contain both fresh and salt water. Observe what happens.

OBSERVATIONS:

1. (a) What happened when the colored salt water was added to the clear fresh water?

(b) Diagram what happened using a colored pencil to indicate the location of the salt water.

2. (a) What happened when the clear fresh water was added to the colored salt water?

(b) Diagram what happened using a colored pencil to indicate the location of the fresh water.
3. Which is denser (heavier) salt or fresh water?

4. If this were an estuary, what would the salt water represent?
   What would the fresh water represent?

5. Describe what happened when the cups containing both fresh and salt water were mixed.

6. In an actual estuary what could cause the fresh and salt water to mix?

7. What effect do you think the mixing of the fresh and salt water in an estuary has on the organisms that live there?

8. In the diagram below, draw arrowheads to the line to show the flow of fresh and salt water in an estuary. Label each line fresh or salt.

   ![Diagram of estuary flow]

9. On the diagram above, place the letter of each statement below (A, B, C, D) where the organism described would be found.

   A. Oysters grow in beds on the bottom of the estuary in mildly salty water.
   B. Striped bass spawn in estuaries where the water is just barely salty.
   C. Other fish spawn in estuaries where the water is entirely salty.
   D. Some organisms spend their lives attached to hard surfaces where the freshwater content is high.

CONCLUSION: In a paragraph, describe what estuaries are, how fresh and salt water mix in an estuary and the effect of this mixing on the organisms that live there.
POLLUTION IN THE ESTUARY

OBJECTIVE: To investigate the effects of pollution on organisms living in the estuary.

MATERIALS:  
- brine shrimp egg  
- 3 - 100 ml culture dishes  
- stirring rod  
- beaker  
- salt  
- distilled water  
- dish detergent (pollutant)  
- hydrochloric acid

Brine shrimp eggs "Sea Monkies" are available from a science supply company or local pet store. You can obtain a weak solution of HCl from your local high school.

PROCEDURE:

1. Prepare a 6% salt solution by mixing 6 ml of salt to 100 ml of water.
2. Pour this solution into three culture 100 ml culture dishes. Label each culture dish as follows: Normal Conditions - Control, Pollutant # 1 - detergent, and Pollutant # 2 - acid.
3. Place 1 drop of brine shrimp eggs into each culture dish.
4. Add one drop of dish detergent to the culture dish labeled Pollutant # 1.
5. Add one drop of HCl to the culture dish labeled Pollutant # 2.
6. Allow all three culture dishes to sit overnight.
7. Observe each culture dish under the microscope and record your observations in the data table. Sketch what you see in each culture dish.
8. Observe each culture dish again after 48 hours and record your observations in the data table. Sketch what you see in each culture dish.

<table>
<thead>
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<th></th>
<th>Control</th>
<th>Pollutant # 1</th>
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<td>Observations after 48 hours</td>
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<tr>
<td>Sketch after 24 hours</td>
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OBSERVATIONS:

1. How quickly are the brine shrimp effected by Pollutant #1, the dish detergent?

2. How quickly are the brine shrimp effected by Pollutant #2, the acid?

3. Assuming that real shrimp would be affected in a similar way as the brine shrimp, what affect would pollution of our estuaries have on the shrimping industry?

4. What effect would pollution of our estuaries have on larger consumers such as birds or fish?

5. Would pollution of our estuaries have any effect on you? Explain your answer.

CONCLUSION: If most of the organisms that live in the ocean spend at least part of their life cycle in the estuaries, explain why you should be concerned about the health of our estuaries. List ways that you could insure the health of our estuaries.
THE DOCK COMMUNITY

The dock community consists of organisms that grow either on a permanent or standing dock that is supported by pilings or on a floating dock that can move up and down with the changing water level caused by the tides. The plants and animals that live in these dock communities are sessile (permanently attached) and must have special adaptations to withstand the ever changing conditions of temperature, light intensity, oxygen, food supply and space.

Barnacles, mussels and oysters can live attached to the pilings of a standing dock. At low tide, when they are exposed, they close their shells to protect themselves from drying out (estivating). At high tide, when covered by water, they open their shells and feed on plankton.

Since the underside of a floating dock is almost always underwater, a greater variety of plants and animals can live there. Some common organisms that might be found on a floating dock on Sapelo include: filamentous brown, green and red algae, sea lettuce (Ulva-a green algae), bryozoans and hydroids (colonial branching animals), bread and other small sponges, and tunicates (sea grapes and colonial tunicates). Organisms such as amphipods, crabs, grass shrimp, polychaete worms and sea spiders nestle among the above mentioned organisms in search of protection and food. (See "Picture Guides for Plankton and Dock Organisms").

Bread sponge (Halichondria bowerbank) is light yellow, low growing and not obvious. Bushy Bryozoan (Anguinella palmata) is dark grey and bushy while in the water, but form thick, limp clumps out of the water. Bugula is a purple, branching bryozoan that has obvious zooids (individual members of the colony). Tubularia crocea is a hydroid with naked, pink polyps and a tube-like stem that can grow up to six inches long. It has two whorls of tentacles and does not have a medusa stage. The hydroid, Obelia, has simple tentacles and grows in delicate brown tufts on a firm surface. The tunicate Mogula manhattensis (sea grape or sea squirt) has a somewhat clear to brownish, tough outer covering (tunic) with an incumbent siphon that brings water into its body and an excurrent siphon to expel water and wastes. All tunicates possess a notochord during their larval stages which makes them a relative to the chordates (animals with a backbone).

All the organisms of the dock community struggle for survival because the estuaries, in which they live, are in constant change. Most are sessile and must depend on the water, tides and currents to bring them food. They are also in constant competition with the other dock organisms for space. Many have developed special adaptations such as: growing larger or faster than their competitors, special methods of reproduction or high reproductive rates, some secrete acids which are poisonous to other organisms, while others trap silt that smothers underlying organisms.

The organisms of the dock community are not limited to growing only on docks and pilings, but may grow on any surface that remains in the water for any length of time such as buoy and ships. In fact, over 2,000 species of marine organisms have been identified living on the hulls of ships. They are often found growing on marine litter such as tires, cans, the shells of dead mollusks and even on the backs of animals such as turtles and whales. If too many organisms grow on a ship's hull or on an animal, they create drag which slows the ship or animal and increases fuel consumption. For this reason, a dock community is often called a fouling community.
THE PLANKTON COMMUNITY

The plankton community is made up of tiny microscopic, floating or weakly-swimming plants and animals. The word plankton comes from the Greek word meaning "wanderer." The plant portion of plankton is called phytoplankton. The term "phyto" comes from the Latin word "Phyton" which means a tree or plant. Zooplankton are the animal portion of the plankton. Zooplankton that spend their entire lives as plankton are known as holoplankton. Meroplankton are zooplankton that spend only their larval stages in the plankton. All types of plankton are drifters and must depend on waves, tides and currents for transportation.

Phytoplankton use the energy of the sun and a chemical compound called chlorophyll to convert carbon dioxide, water and minerals into edible carbohydrate, proteins and fats. In this process, called photosynthesis, oxygen is given off as a by-product. Two-thirds of all the photosynthesis that takes place on the earth occurs in the oceans. It has been estimated that phytoplankton produces 80% of all the oxygen on earth. Therefore, phytoplankton, often called "pastures of the sea," are not only important as a basis of the marine food web but also as a source of oxygen for the entire earth as well. Phytoplankton are much more abundant in estuaries than they are in the open ocean. In estuaries, like those around Sapelo, drainage from fertile upland soils supply the phytoplankton with the nutrients they need to carry on photosynthesis.

Diatoms, with more than 20,000 species, are the most abundant phytoplankton. They are one-celled, yellow-green algae. Their cell wall or shell is made of glass-like silica with one half of the shell fitting over the other half like the lid on a box. Many diatoms contain a droplet of oil that aids them in floating. They exist in numerous shapes and prefer cool water habitats. Diatoms are considered the single most important food source in the ocean and are eaten by zooplankton as well as larger organisms.

Another type of phytoplankton, dinoflagellates, were once thought to be animals since they have tiny whip-like tails, called flagella, that enable them to move in a swirling or jerking motion. They are considered plants however, since they contain chlorophyll and photosynthesize. Dinoflagellates are second only to diatoms as important food producers. Dinoflagellates prefer warmer waters. The so called "red tides" are produced by two species, Gonyaulax and Gymnodinium, when they reproduce rapidly creating water conditions that are toxic to many fish. Another dinoflagellate species, Noctiluca, exhibit bioluminescence or give off a light which is a chemical reaction produced without heat. These dinoflagellates (along with some bacteria and comb jellies) create the white or greenish dots of light that are so often seen in the ocean on warm nights.

The permanent members of the zooplankton community (holoplankton,) are foraminifers, radiolarians and copepods. Foraminifers and radiolarians are microscopic-like diatoms and dinoflagellates. Foraminifers (hole-bearers) live within tiny shells made of calcium carbonate, while the shells or skeleton of radiolarians are made of silica. Copepods are much larger and more numerous. In fact, copepods are thought to make up 70% of the zooplankton population. Copepods move around or "tread water" by beating their limbs as many as 600 times a minute, F-9
thus the Greek meaning of their name "oar-footed." Copepods feed on phytoplankton and are a major food source for such animals as the 45-foot-long Basking Shark and the 60 foot long Whale Shark.

Members of the zooplankton community migrate vertically within the ocean water column during the day. They generally confine themselves to a lower level during daylight hours, then migrate to the surface at night to feed on the phytoplankton.
| **Diatoms (Phytoplankton)** | **Diatoms (Phytoplankton)** | **Dinoflagellates (Phyto.)** | **Gymnodinium**  
Dinoflagellate-Phytoplankton |
|---------------------------|-----------------------------|-----------------------------|---------------------------------|
| **Gonyaulax**  
Dinoflagellate-Phytoplankton | **Noctiluca (Dinoflagellate)**  
Phytoplankton | **Foraminifera-Zooplankton**  
(Holoplankton) | **Radiolarians - Zooplankton**  
(Holoplankton) |
| **Tintinnid -Holoplankton** | **Copepods - Holoplankton** | **Ctenophore- Holoplankton** | **Rotifer - Holoplankton** |
| **Ostracod - Holoplankton** | **Branchopod - Holoplankton** | **Cypris larva:**  
Nauplis larvae: | **Skeleton shrimp:**  
Scud: |
| **Zoea:**  
Megalops: | **Arrow:**  
Polychaete:  
Flat: | **Sea Urchin:**  
Starfish:  
Sea Cucumber: | **Egg:**  
Echinoderm Larvae  
Fish Larvae |
| **Nauplial Crab Larva:**  
Worm Larvae |
<table>
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<tr>
<th>Tunicate Larvae</th>
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<td>Grass Shrimp</td>
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<td>Sea Lettuce (<em>Ulva</em>)</td>
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<td>Encrusting Bryozoan</td>
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<td>Bread Sponge</td>
<td>Red Beard Sponge</td>
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DOCK AND PLANKTON STUDY

OBJECTIVE: To observe and identify the organisms of the plankton and dock communities.

MATERIALS: small plastic bucket
zip-lock bags
formalyn (see safety note)
cooler
putty knife or scraper
eyedropper
Plankton and Dock Community fact sheets
Picture Guides for Observing Plankton and Dock Organisms

dissecting and/or compound microscope
hand lens
slides and cover slips/depression slides
flat-bottom, glass bowl (finger bowl)
light source

PROCEDURES: Students should read the dock and plankton community fact sheets.

I. COLLECTION PROCEDURES:
   A. To collect dock specimens: Go to the lowest part of the floating dock and lie down on your stomach. Carefully reach under or on the side of the dock and gently pull or scrape off some of the material growing there. Place this specimen in a small bucket and cover it with several inches of water. Your specimen may be observed immediately or placed in a zip-lock bag, then placed in a cooler and taken back to the classroom. If kept cool, the specimen will last a couple of days. To permanently preserve the specimen, add a few drops of formalyn (5% solution). Back in the classroom, transfer these permanently preserved specimens into a glass jar.

   ***SAFETY NOTE: Use gloves and goggles when handling formalyn.

   B. To collect plankton: (Note: Most of the time, the dock specimen will have ample plankton for study). Use a commercial or homemade plankton net and drag the net slowly through the water (or throw it away from you, then pull it toward you). Before pulling the net completely out of the water, dip it up to the rim several times. This will wash the plankton down into the collection jar. Remove the collection jar and screw the cap on. Place this specimen in a cooler.

II. OBSERVATION PROCEDURES:
   A. To observe dock specimens: Transfer the dock specimens into a wide-mouth, flat bottom bowl or finger bowl and cover with sea water. Observe using a dissecting microscope or hand lens. Use the "Picture Guide for Identifying Dock and Plankton Organisms" to identify the organisms present.

   B. To observe plankton samples: Remove the top from the specimen jar and place it near a light source for a few minutes (light attracts plankton). Use an eyedropper and draw a sample from the side of the jar near the light source. Place this sample onto a slide and
cover it with a cover slip or use a depression slide. Make several slides. Observe the slides first using a compound microscope. Observe and identify the plankton present.

**OBSERVATIONS:** Use the "Picture Guides to Dock and Plankton Organisms" and your specimens to fill in the chart below. You may not have pictures of all the organisms you observe.

<table>
<thead>
<tr>
<th>Name</th>
<th>No. Observed</th>
<th>Written Description</th>
<th>Drawing</th>
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Answer the following:
1. How many different types of organisms did you observe in the dock sample? _________
   In the plankton sample? _________
2. How many different types of organisms were you able to identify? _________
3. Comment on the variety of organisms in each sample.
4. List some of the unique characteristics of the plankton you observed.

5. List some of the unique characteristics of the dock organisms you observed.

USE THE DOCK AND PLANKTON COMMUNITY FACT SHEETS TO ANSWER THE FOLLOWING.

1. What is plankton?
   How did it get its name?

2. List and define the two major sub-divisions of plankton.

3. Why is phytoplankton so important?

4. Explain the major differences between diatoms and dinoflagellates.

5. If dinoflagellates have animal-like flagella, why are they considered phytoplankton?

6. Which group of phytoplankton is the single most important food source in the ocean? _______
   Explain why.

7. List and describe the two types of zooplankton.

8. What is the major difference between foraminiferans and radiolarians.
   What type of zooplankton are they? ____________________

9. What organism(s) make(s) up the greatest percentage of zooplankton? ____________________

10. Describe the major similarities and differences in phytoplankton and zooplankton.

11. In your opinion, what would be the advantage for barnacles, oysters, crabs, fish, shrimp and most other marine organisms to spend their larval (baby) stages in the plankton?

12. What does the term sessile mean? ____________________

13. Why do dock community organisms need special adaptations in order to survive?

14. List several of the special adaptations of the dock community organisms.
15. What does the term estivating mean? Which animals have adaptations to prevent estivating? How do they do this?

16. Why is there a greater variety of organisms living on a floating dock than on the pilings of a permanent or standing dock?

17. Why is a dock community often called a fouling community?

18. Very large crude oil tanker ships transport crude oil from the Persian Gulf 20,000 nautical miles across the Atlantic Ocean to a port in Brunswick. These tankers burn 1,100 barrels of fuel every twenty-four hours. They average 15 knots (15 nautical miles per hour) when their hull is clear of fouling organisms and 12 knots when their hull is fouled. A barrel of fuel costs $30.00. Calculate the cost of a round trip if the hull is clean. What would the round trip cost be if the hull is fouled?

CONCLUSION: In a paragraph, discuss plankton and dock organisms. Include a discussion of the number and variety of plankton and dock organisms. Explain the importance of these organisms to the marine food web and explain why they are dependent on a healthy estuary.

FOR FURTHER RESEARCH:

1. How and how often are ships dry-docked to remove fouling organisms?
2. How are fouling organisms removed?
3. What has been added to the paint used on the hulls of ships to prevent fouling organisms from growing on them? Are these additives environmentally safe? Explain.
4. Interview a coastal shrimper. Ask questions such as: the average speed of a shrimp boat, the cost per gallon for fuel, average number of miles traveled in a day, how much does a fouled hull reduce the speed of the shrimp boat? Then calculate the average cost of operating a shrimp boat. Also ask how often the boats are dry-docked for cleaning, and the cost. Have them describe how their boats are cleaned.
5. Visit the beach and list the items that have washed up onto the beach that have fouling organisms growing on them.
Intertidal mud flats are located along the edges of the salt marsh. This harsh habitat is covered by water at flood (high) tide and exposed to the scorching sun at ebb (low) tide. It consists of a soggy substrate (soil) made up of clay and silt that is deposited during slack tide. Slack tide is the brief period between flood tide and ebb tide during which the water is not flowing in or out but is still. Only the upper layers of this muddy substrate contain oxygen. The deeper layers contain decaying organic matter that gives off a hydrogen sulfide gas that causes a rotten egg smell.

Only a few plants and animals live in the tidal flats, but those that do are an important food source for larger animals. Phytoplankton and algae grow on the surface of the mud (giving it a greenish tint) and attached to hard surfaces such as old shells or logs. Insects breed in small pools and the larvae feed on algae and zooplankton. Buried animals such as cockles, whelks, amphipods, lugworms and fiddler crabs eat microorganisms that are trapped in the mud. When the tide comes in, phytoplankton, algae and zooplankton serve as the food source for filter feeders (oysters, clams, mussels, barnacles), and several types of worms including the parchment tube worm. Shrimp and crabs eat worms, while crabs and flounder eat shrimp. Also at high tide, organisms that always live in the water come in to feed. Blue crabs and several species of hermit crabs scavenge for food while fish such as the mummichug, silversides, spot and croker feed on insect larvae, zooplankton and small fish.
When the tide goes out, the muddy substrate is exposed and fiddler crabs come out of their burrows and sift through the mud for food while periwinkle snails eat algae off the surface of the mud. Mud snails scavenge the surface, eating both living and dead organisms. Wading and shore birds like egrets, clapper rails, gulls and sandpipers come in to eat the snails, worms, fiddler crabs or any other floating or crawling animal. Oyster catchers feed off the oysters, mussels and clams. Raccoons also venture onto the mud flat to feed on whatever they can find.

The animals that live in or on the mud flats are important food sources for larger animals and any disturbance of this harsh but fragile habitat could have grave consequences for the food chain.

Can you identify the mud (tidal) flat organisms in this picture?

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Salt marshes form on the landward borders of the estuary. Georgia's coastal marshes cover a four to six mile border between the barrier islands and the mainland. Third in acreage only to Florida and Louisiana, Georgia's more than 475,000 acres of salt marsh make up more than 30% of all the salt marshes along the Atlantic coast and produce more food and energy than any other estuarine zone on the entire eastern seaboard. *Spartina alterniflora*, the major producer of the marsh, produces 17.8 tons of biomass per acre annually making it second only to sugar cane in productivity. (One acre of corn only produces 5.7 tons of biomass annually.)

Tides are the heartbeat of the salt marsh. Twice a day tides flood the marshes, nearly covering the grasses. Tidal creeks carry water, dissolved chemicals such as nitrogen and phosphorus (natural fertilizers), and nutrients stirred up from the bottom to all parts of the marsh. This provides food not only for the plants but for invertebrates as well and brings in fish to feed and breed. The ebbing waters of low tide transport a murky soup of dissolved nutrients, marsh grass, detritus and small animals (dead and alive) back out to the estuary where they become food for other marine organisms.

The harsh conditions facing organisms living in a salt marsh require special adaptations to the rapid changes in salinity and temperature and frequent changes in water-level. The substrate (soil) of the marsh is fine-packed mud and silt which is oxygen poor. Here anaerobic (without oxygen)
bacteria decay organic matter and release hydrogen sulfide (which smells like rotten eggs), methane, and iron compounds.

Only specially adapted salt-tolerant plants live in the salt marsh. Diatoms and other phytoplankton live and grow on the surface of the marsh mud. The dominant plant, _Spartina alterniflora_, covers 73% of the marsh. The cell membrane of the root epidermal cells inhibits the entry of salt. Root hairs and cortex cells concentrate the salt and draw the water into the roots where it is then pumped to the rest of the plant. The stems of the _Spartina_ are hollow and carry oxygen down to the roots. The leaves produce epidermal glands that excrete excess salt. Although _Spartina_ produces over half of the food in the marsh food web, only a few animals (insects and periwinkle snails) eat it directly. It is only after it dies, decays and turns into detritus, a process taking about a year, that it becomes the major food source for marine life.

Plants in the salt marsh are found in distinct zones depending on the soil type, salinity, temperature and tidal fluctuations. _Spartina alterniflora_ grows from one foot to ten feet in the low marsh nearest the waters of the sound and tidal creeks where it is almost covered at high tide. In the high marsh where there is more sand mixed with the mud and where it is only covered by a few inches of water at high tide the _Spartina_ only grows from three inches to about a foot. _Spartina patens_ (salt meadow cordgrass or salt meadow hay) grows in the high marsh and along the marsh boarders where the soil is more sandy and there is less water. Black needle rush (_Juncus roemerianus_) also grows abundantly in the high marsh. Other common plants in the high marsh include sea lavender (_Limonium carolineanum_), glasswort (_Salicornia virginia_), spike grass (_Distichlis spicata_) and sea oxeye daisy (_Borrichia frutescens_).

Salt pans and hammocks are interesting features of the high marsh. Salt pans, bare sandy spots, mark the highest tide level and form when very high tides cover the area with thin sheets of water. The sun evaporates the water leaving the salt behind. The salt content of a salt pan is too great for plants to grow. Hammocks are small tree islands that form within the expanses of the marsh. They form where sediments have accumulated forming a higher area where
the water seldom reaches and the soil has become richer. These hammocks are filled with bayberry (wax myrtle), yaupon holly, red cedar, palmettos, prickly pear, yucca, and various vines.

The animals of the salt marsh also have to have special adaptations to live and feed there. Spiders feed on the insects that eat the marsh grass. The periwinkle snail (*Littorina irrata*) crawls up and down stalks of *Spartina* eating algae and detritus. The mud snail and coffee bean snail scavenge debris from the mud. Ribbed mussels grow in clumps at the base of the marsh plants and filter nutrients from the water brought in by the tides. Fiddler crabs eat the detritus and algae in the mud and scrape food from the sand, then expel or spit out the sand in neat little balls. Square back crabs often can be found in the upper marsh. At high tide young fish, shrimp and crabs swim into the marsh to find food and shelter. Larger fish, spots, drums, crokers, and crabs also come in to feed.

At low tide, land-based animals like the diamondback terrapin feed on crustaceans and fish. Mammals like raccoons, mink and sea otters feed on shellfish and other animals left in the tide pools. Birds like the red-winged black bird and the seaside sparrow frequent the marsh in search of insects; clapper rails feed on fiddler crabs and insects while willets, egrets and herons often walk the muddy banks of the marsh's edge in search of shrimp, small fish and fiddler crabs.

The salt marsh is extremely important to the health of the marine ecosystem. It provides food, breeding grounds and protection for hundreds of species of plants and animals. It partially filters pollutants and sewage from the water before it reaches the estuary. Georgia is fortunate to have more marshlands than any other state on the east coast and it is the responsibility of every citizen to ensure its well-being.
CREATE AN INVERTEBRATE

SCENARIO:

It is the year 2050 and due to overfishing, pollution of the estuaries and habitat destruction many species of shrimp, crabs, and shellfish that were a popular food source in the 20th century are disappearing. You are a marine biologist who has been hired by the University of Georgia Marine Institute to create a new species of invertebrate that can live in the salt marsh estuary. Your new invertebrate will be different from the invertebrates of the 20th century because it will be able to eat the stems of *Spartina alterniflora* (smooth cord grass), the primary plant of the salt marsh. Your invertebrate is to be a food source for man as well as the marine organisms that depend on invertebrates for food.

Your invertebrate must have special adaptations to enable it to survive the harsh conditions of the salt marsh estuary: rapid changes in temperature, salinity, water depth, and oxygen supply. It must also have special adaptations to protect it from predators. It will need to have a predator or predators so that it will not become overpopulated and deplete the salt marsh grasses. Your invertebrate should also have some type of adaptation to enable it to live in the polluted environment of 2050. It should not look like any known invertebrate! *Use your imagination and be creative.*

You are to write a newspaper article describing your new creation. In the article you should explain the following:

A description of your invertebrate.
How your invertebrate is adapted to living in its environment.
How your invertebrate obtains it food? (Does it have any special appendages for food getting?)
Does it move? If so how.
How does your invertebrate reproduce? (Sexually or Asexual). How is fertilization accomplished?
How do the juveniles develop? Do they begin their life looking like the adult or in a planktonic form? Explain where in the estuary the juveniles live and their adaptations for survival.
Describe the predator or predators of your invertebrate. What defense mechanisms or special body structures does it have to enable it to hide or escape predation?

Draw a picture of or create a three dimensional model of your invertebrate.

Give your new creation a scientific and common name. *Scientific names are written with the genus capitalized and underlined or italicized while the species name is in lower case and underlined or italicized.*

Present your new invertebrate to the class.
"TOO MANY CRABS"
A FIDDLER CRAB POPULATION EXERCISE FOR THE CLASSROOM

OBJECTIVE: To develop skills in estimating population sizes.

MATERIALS: Copy of "Too Many Crabs:" A Fiddler Crab Colony
Index card
scissors
pencil or pen
ruler

BACKGROUND INFORMATION:

Fiddler crabs are among the most abundant animals of the estuary. They live in burrows dug into the mud of the marsh and tidal flats. The fiddler crab got its name because the male has one large claw that it waves back and forth both in an attempt to attract a mate and in defense of its territory. They have eyes on stalks that extend out from their body to enable them to see in all directions. When a predator approaches, these tiny crabs scurry sideways and disappear into their burrows. The male, which is somewhat more colorful than the female is the first to enter its burrow and the last to return to the marsh or tidal flat after the predator leaves.

The fiddler's burrow serves three purposes: protection from predators, protection from high tide and as a place for mating. Using legs and claws, the fiddler digs his hole to a depth near ground water where the dirt is moist. They roll and push the excess dirt into a ball that is then carried away from the entrance. These are called "housekeeping balls". At low tide the fiddler comes to the surface and feeds by scraping morsels of food from the grains of sand. He rolls the sand into very small balls (smaller than the housekeeping balls) after all of the food has been removed. When the tide comes in, the fiddler returns to his burrow sealing the entrance with a thick plug of mud to prevent himself from drowning.

Scientists often need to count or take a census of the number of fiddler crabs in an area in order to determine the range, health and productivity of the population. Instead of counting every fiddler, scientists estimate the total number of a particular species by doing a quadrant study or random sampling. Scientists divide the area to be studied into a series of sections, all the same size (a quadrant). They then count the number of crabs in only a few quadrants and get an average number of fiddlers per quadrant. Next, they multiply the total number of quadrants by the average number of fiddlers in the quadrants they counted. This number is an estimate of the total of fiddlers in the entire area being studied. It has been estimated that there are more than eight million fiddler crabs per acre of marsh on Sapelo Island.

PROCEDURE:
Assume that there is only one fiddler crab per burrow.
Do not count all the crabs on the page.
1. Cut a one inch square from an index card or some other stiff paper. This is your quadrant.
2. Lay your copy of the fiddler crab colony on a flat surface.
3. Drop the paper quadrant onto the colony and trace around it.
4. Count the number of crabs in or on the square. Place this number in your data table.
5. Repeat steps three and four, nine more times. Add all 10 trials to get the total number of crabs. Divide your total by 10 for an average. Place this number in your data table as the average number of crabs per square inch.
6. Use your ruler to measure the length and width of the crab colony. Multiply the length and width of the colony to find the total number of square inches or total area of the colony.
7. Next, multiply the total area (total number of square inches) by the average number of crabs in a square inch. This will be your estimate of the number of crabs in this crab colony.
8. Next, obtain each of your fellow students estimates and find the class average by adding all the estimates and dividing by the number of students in the class.

**OBSERVATIONS:**

**Data Table:**

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<td>Trial 10</td>
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<tr>
<td>Total</td>
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<tr>
<td>Total area of colony</td>
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<tr>
<td>Your estimate of the # of crabs</td>
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<tr>
<td>Average of entire class estimate</td>
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Answer the following questions:

1. Why do you think different people got different averages?

2. How far from the class estimate of the number of crabs in the colony was your estimate?

3. Do you feel that the class estimate is a fairly accurate estimate of the number of fiddler crabs in the colony? Explain why or why not.

4. Why do you think that scientists use quadrant studies to measure populations of organisms?

**CONCLUSION:** Explain how scientists obtain the total population of a group of organisms in an area that is too large for them to count the organisms.
"TOO MANY CRABS" A FIDDLER CRAB COLONY
Maritime Climax Forest

The maritime climax forest forms upland from the marsh and is the last stage of natural succession on an island. The live oak is the dominant plant and forms the canopy layer of the forest. These majestic trees have adapted to the soft, sandy, nutrient-poor soil through well-developed root systems that anchor them and tap groundwater. They have strong trunks with twisting branches that help protect them from the strong winds and their broad, thick, leathery evergreen leaves help them to fend off the salt spray from the ocean and to retain moisture. The live oak is long-lived and slow growing. It has often been said that it takes a live oak a hundred years to grow, a hundred years to live and a hundred years to die.

The branches of the live oak are draped with Spanish moss and resurrection fern. These are not parasites but epiphytes, which are air breathing plants. Spanish moss uses the tree only for support and gets its nutrients from rainwater and debris falling from the tree. Resurrection fern is an indicator of the moisture conditions because when water is plentiful, it grows green and opens its leaves. When conditions are dry, it turns brown and shrivels stopping photosynthesis and reducing its surface area to conserve water. The reddish patches on the trunks of the tree are blood lichen which is actually a fungus and a bacteria growing together in a symbiotic relationship. The southern magnolia, red maple, laurel and hickory oak are often found dispersed among the live oaks. The thick canopy of the forest shades the understory and traps moisture.
creating a humid environment. The understory plants include the cabbage palm, sawtooth palmetto, red bay and yaupon holly. Various vines such as poison ivy, virginia creeper and muscadine grape are also abundant.

Because Sapelo was once heavily deforested by man, true maritime forests are found only in patchy areas. Pine thickets and grassy fields now occupy much of what was once climax forest. Georgia's live oaks were once used to build ships. The Constitution ("Old Ironsides") was built from live oak timber from Georgia's sea islands.

The leaf litter of the forest is decomposed by fungi and invertebrate decomposers such as beetle grubs, millipedes and termites. These insects and the seeds, herbs, grapes and other fruits, leaf buds, flowers and nuts (mainly acorns) are the food source for the herbivores of the forest. These herbivores include rats, mice, song birds, lizards, rabbits, squirrels, wild turkey and deer. Sapelo also has Chockalaca (a pheasant imported from South America). The great horned owl, snakes and raccoon are the major predators of the maritime forest.

The live oak is important because it is a deterrent to fires (its leaves and trunk do not burn well) and because it provides food, water, cover and nesting area for a large number of mammals, birds, reptiles, amphibians and insects. Many of these animals spend their entire life cycles under the shelter of the live oak canopy.
A unique and important habitat of a barrier island is the slough. These form parallel to the shoreline in low-lying depressions often between ancient dune ridges. During rainy periods (from March to September and from December to January) these depressions fill with water from runoff and eventually fine sediments and detritus seal the bottom so water can be permanently retained. The water in the sloughs is stained brown by the decaying plants (tannin). These wetland areas provide food and breeding ground for frogs, insects, fish, migratory ducks, herons, egrets and alligators. Freshwater plants like cattails, mosquito fern, water hyacinth, water lilies, bladderwort, cypress, willow and cottonwood thrive here. During dry periods, September to December and February to March, the water level drops and sloughs may even dry up. When the water level drops, the organisms living in sloughs are concentrated in a smaller area providing an excellent food source for birds. Plants of the slough die and decompose, returning important nutrients to the soil.

Sloughs may be seasonal or grow larger and form ponds. No matter how long they last, sloughs are important ecosystems because they aid in flood control by absorbing rainfall and hurricane surges. They also trap pollution, recharge the groundwater, and provide fresh water, food and shelter for migratory birds, insects, frogs, fish and alligators. Though many fear him, the alligator is probably one of the most important animals on a barrier island. They dig deep holes called care
dens for their young. These extend about six feet below the bottom of the pond or slough. During times of drought, these care dens or "gator wallows" are the only source of freshwater for the other animals of the island.

On Sapelo several small sloughs can be seen along the nature trail from the big house to the beach. The duck pond on the north end of the island is a freshwater pond that probably began as a slough.
Toward the beach from the maritime forest and usually covering old dune ridges is an area characterized mainly by dwarfed trees and shrubs. The "Toothache Tree", wax myrtle, red cedar, yaupon holly along with yucca, saw palmetto and numerous vines stand as sentinels against the salt spray from the ocean. As waves roll in from the ocean, droplets of seawater are tossed into the air and blown ashore by the wind. Because salt is a killer mineral for plants, their growth is stunted and they grow with their crowns flattened and their branches low to the ground. As a result of this "salt pruning," the trees and shrubs are noticeably flattened on the windward side.

This low growth provides food and cover for a variety of animals like insects, rodents, lizards, meadow mouse, snakes, cottontail rabbits, deer and a variety of birds.
Sand dunes form between the shrub zone and the beach. Older stabilized dunes called secondary dunes usually exist between the shrub zone and the newer, usually higher, less stable primary dunes. A sand dune forms wherever sand blown by the wind can be trapped by plants and debris. Wind velocities of 12 miles per hour or greater are capable of moving fine, dried beach sand. The formation of dunes is dependent upon the direction of the prevailing winds and fair-weather winds move more sand, subsequently producing more dunes than do storm winds. Storm winds, because they are accompanied by strong waves and rain, generally erode dunes.

Because they are made of sand, dunes are not static but are in a constant state of migration landward and along the coastline. Dune grasses such as panic grass and sea oats are vital to the building and stability of the dunes. These plants have the ability to resist salt spray and burial by the sand. When wind strikes the blades of these grasses, its velocity is slowed and sand is dropped and piled up. The sea oats and panic grass have the ability to grow upward through the sand enabling the dunes to build higher. They also have extensive root systems that can extend downward as far as 30 feet, thus helping to stabilize the dunes. These root systems have propagation rhizoids that extend horizontally, making the sea oats less dependent on seeds for
new growth. Eventually, plants such as sea rocket, saltwort, dusty miller, pennywort, beach elder, saw palmettos, prickly pear, yuccas, beach croton and morning glory invade the dunes. All of these dune plants have special adaptations such as thick, waxy, fleshy or furry leaves and many grow close to the sand to conserve moisture and to avoid salt spray and wind.

Animals that inhabit the dunes must also have adaptations for living in the desert-like conditions. During the day when temperatures can reach 120° F the animals like the ghost crab dig into the sand. Sand dune insects like tiger beetles and wasps have a dense fur covering their bodies to insulate them against the heat. Other animals like the dune grasshopper, wolf spider, ghost crab and young sanderlings have color adaptations so they blend in with the sand to escape their predators. Most dune animals including rabbits and mice visit the dune in search of food during the late afternoon or at night when the temperatures are cooler. Many birds like terns nest in the dunes and let the natural heat incubate their eggs. Many times the only evidence of animals in the dunes are the tracks they leave behind.

Sand dunes are vital to the survival of the island. They are the first line of defense against the effects of the wind and waves and protect the interior of the island from these erosional forces. Often dunes are eroded away during storms, but they soon rebuild. Building too near the sand dunes can endanger the dunes and thus can endanger the whole barrier island they protect. Disturbing, damaging or destroying dunes to build private homes and commercial buildings such as hotels, restaurants and shops is impractical and dangerous. Without the protection of dunes the beach will erode quickly and destructively. It is actually in the best interest of builders to keep well behind the dunes so that the dunes can protect their precious structures from certain battering by the sea, wind and salt they would suffer without such protection.

Sapelo has one of the longest natural dune systems on any of Georgia's islands. It is important to remember that dunes are fragile and very susceptible to the presence of man. Walking on the dunes can break the delicate plants and create areas where water can overwash behind the dunes and increase their erosion. The picking of sea oats is not only detrimental to the dunes but it is also against the law, requiring heavy fines of $500 or more.
The beach forms at the edge of an island between the ocean and the sand dunes. The sand is deposited by waves and currents and is then blown around by the wind to create dunes. The beaches of Sapelo and Georgia's other undeveloped islands are made mostly of fine-grain sand. The beaches are fairly wide and slope gently toward the ocean. This harsh environment is a moderate energy area because the waves from distant storms release their energy as they roll up onto the beach. Winds keep sand in constant motion. In the summer the prevailing winds along the east coast blow from the southwest and in the winter from the northwest. The profile of the beach changes from a broad flat beach in the summer to a narrower and steeper beach in the winter.

All beaches have different parts or zones, although all the zones may or may not be present at any one time. The backshore is the area from the dunes to the berm and is an area rarely touched by wave action. The berm marks the highest limit of storm waves. On beaches where high tide goes all the way to the dunes, the backshore and berm will not be noticeable. The foreshore is the area between high and low tide often called the intertidal zone. Usually beyond the low tide line there is a longshore trough (through which longshore currents travel) and beyond that a longshore sandbar or series of sand bars. The area where waves break is called the inshore or surf zone and is usually over the longshore sand bars. Waves roll up onto the beach in a thin sheet of water. This area is called the swash zone.
The organisms characteristic of a beach must be adapted to these and other harsh conditions. They must be able to withstand the crashing waves and periods of inundation by sea water at high tide. They must be able to survive the hot, beating sun and wind during low tide, and the freezing cold of winter. Many organisms like the ghost shrimp, polychaete worms, coquina clams, mole crabs, isopods, amphipods and sand dollars burrow into the sand. They are either filter feeders and use their antennae to extract food from the water or scavenge the algae and detritus from between the sand grains. Gastropods like the oyster drill and moon snail and whelks actively prey on other animals. At low tide, a large variety of shorebirds, raccoons, insects and ghost crabs visit the beach to feed.

Algae is the only characteristic plant of the beach. Algae lives between the grains of sand and occasionally adds a green, gold, pink or purple tint to the sand. Other plants like Ulva (sea lettuce) and sargassum (a brown algae or seaweed) are often washed up onto the beach.

The wrack line or strand line is a line of debris that often runs parallel to the water's edge and marks the high tide line. This wrack line is made up of a mixture of man-made materials that have washed up onto the beach and decaying marsh grasses. This wrack, though unsightly, is important. It provides an ideal environment for microorganisms, amphipods and insects. The marsh grasses decay over a period of a year and become detritus which is a major marine food source. The grass and other materials in the wrack play an important role in the building of new dunes by capturing sand and seeds allowing new dunes to form.
SAND INFORMATION SHEET

Scientists define sand as unconsolidated (loose) grains of minerals and rock that are less than 2.1 mm (1/2 inch) but more than .06 mm (1/400 inch) in diameter. Aeronologists, scientists who study sand, can "read" the history of sand and tell it's source, the climate of the area where it originated, the distance and environments it traveled through, and what the environment was like where it was found.

There are four common sources of sand: weathering on continental granitic rock, weathering of oceanic volcanic rock, skeletal remains of organisms, and precipitation from water. Sand is either biogenic, if it originated from an organic (once living) source, or abiogenic, if it is inorganic (was never living).

Sand that originated from granitic or volcanic rock or precipitation is abiogenic whereas sand made from skeletal remains of organisms is biogenic. Continental sands that come from granite are rich in quartz, feldspars, and micas. The darker grains in continental sands are various heavy minerals, the composition of which is generally characteristic to the area they come from. The whiter a continental sand is the more quartz it contains. Quartz is the most stable of the common minerals on the earth's crust, thus, the farther a continental sand travels, the richer in quartz it becomes. The other less resistant minerals have broken down and dissolved in the water. The grains become more rounded and well sorted, making them more mature, the farther they travel. Volcanic oceanic sands are rich in basalt and have very little or no quartz. Most volcanic oceanic sands come from volcanic islands. Precipitate sand grains form by the precipitation of mineral material (predominately calcium carbonate) dissolved in water. Skeletal sands are made of the remains of animals and plants and generally have not traveled very far from their source. The size of skeletal sands depends on the skeleton they came from and the amount of exposure to wind and waves. Most skeletal sands come from tropical regions.

The types of minerals a sand contains determines its color. The texture or size of the sand grains is important. The smaller the particle of sand, the easier it is for the waves to pick it up and carry it along. The texture of the sand determines the type of beach that will be formed by the waves. Coarse sands result in a steep beach while fine sands form smooth, hard packed, gently sloping beaches.

The sand on Sapelo and Georgia's other beaches originated from rocks in the Appalachian Mountains. Through thousands or millions of years of chemical and physical weathering and subsequent erosion, the sand first traveled to streams, then to rivers and eventually to the ocean. Once in the ocean, it was picked up by waves and currents and eventually deposited on the beach. On their way to Sapelo, the sand particles underwent abrasion by being rubbed against other sand and rock particles. The farther a grain travels, the rounder it becomes.
SAND SLIDE PREPARATION METHODS

WHEN PREPARING SAND SLIDES ALWAYS KEEP THE SAND SAMPLES SEPARATED. USE DIFFERENT TABLES SO THAT THE SAND FROM ONE AREA DOES NOT GET MIXED IN WITH SAND FROM ANOTHER AREA!

GLASS SLIDE METHOD:

Materials: glue mixture (1/2 glue and 1/2 water), glass slides, q-tips, labels for slides, pen, and sand samples
Procedure: 1. Place a label on each slide and write the location it came from and the date collected.
2. Use a q-tip to smear a small amount of the glue mixture onto the center of the glass slide.
3. Sprinkle a few grains of sand onto the slide and let dry. REMEMBER: Less is best. (the grains of sand should not touch each other).
4. The slides can be stored in a slide box.

PAPER SLIDE METHOD:

Materials: manila folders, index cards or some other stiff paper, clear tape, single edged razor blade and sand samples
Procedure: 1. Cut the manila folders, index cards, or stiff paper into 1 1/4 inch by 3 inch rectangles.
2. Use a single edge razor and carefully cut out the center of each rectangle. (See the diagram below for exact dimensions of cut)
3. Label slide with location and date the sand was collected.
4. Place a strip of clear tape on the back side of the paper slide.
5. Sprinkle a few grains of sand onto the tape.
6. Repeat steps 3 - 5 for each sand sample.

CLEAR TAPE METHOD:

Sprinkle a few grains of sand onto a strip of clear tape. Cover this strip with another strip. Trim the edges. Use a pen to label the location and date the sample was collected.
MAKE YOUR OWN SAND SLIDES

DIRECTIONS: Copy this page onto cardstock or some other stiff paper.
### How To Classify Your Sand

<table>
<thead>
<tr>
<th><strong>Biogenic/Orogenic</strong></th>
<th><strong>Olivine Green</strong></th>
<th><strong>Oblister</strong></th>
<th><strong>Volcanic</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantity</strong></td>
<td>Clear</td>
<td>Black, gray, translucent</td>
<td>Black, gray, translucent</td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td>Green</td>
<td>Black, green, pink</td>
<td>Black, green, pink</td>
</tr>
<tr>
<td><strong>Texture</strong></td>
<td>Glassy</td>
<td>Black, green</td>
<td>Black, green</td>
</tr>
</tbody>
</table>

### Composition

<table>
<thead>
<tr>
<th><strong>Mineral</strong></th>
<th><strong>Majority</strong></th>
<th><strong>Grain Shape</strong></th>
<th><strong>Texture</strong></th>
<th><strong>Sorting</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Poorly sorted</td>
<td>Well rounded</td>
<td>Most edges rounded</td>
<td>Very angular</td>
<td>Poorly sorted</td>
</tr>
<tr>
<td>Intermediate sorted</td>
<td>Almost round</td>
<td>Some edges rounded</td>
<td>Very angular</td>
<td>Intermediate sorted</td>
</tr>
<tr>
<td>Well sorted</td>
<td>Round</td>
<td>Almost round</td>
<td>Almost round</td>
<td>Well sorted</td>
</tr>
<tr>
<td>Poorly sorted</td>
<td>Flat</td>
<td>Flat</td>
<td>Flat</td>
<td>Poorly sorted</td>
</tr>
</tbody>
</table>

### Note

- **Seaweed stones:** needle-like, brown, black, green, purple, white
- **Spotted shells:** clear or white, have pointed edges
- **Shell fragments:** bisected shell, broken, gray, white, usually not shiny
- **Interlocking:** tiny white shells
- **Foraminifers:** tiny shells with a hole in them
- **Combs:** variety of corals, small rounded holes in each grain
- **Algae:** very thin, round, brown, lavender, pink, green, white

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THE SANDS OF SAPELO

OBJECTIVES: 1. To classify sand grains according to texture, sorting, shape, maturity and mineral composition.
2. To investigate the origin of the sand on Sapelo.

MATERIALS: Sand samples (from the base of the dunes, midway to the ocean, and the swash zone)
Materials to make sand slides (see Sand Slide Preparation Methods sheet)
Sand Information Sheet
Barrier Island Migration and Natural Erosion Fact Sheet
How To Classify Your Sand sheet
Sand Classification Chart
Stereo/dissecting microscope, discovery scope, or hand lenses
Maps of Georgia's Rivers and Counties

PROCEDURE:
1. Collect sand samples from the base of the sand dunes, midway to the ocean, and near the swash zone. (A film container full will be enough for several years)
2. Prepare sand slides following one of the three methods described on the Sand Slide Preparation sheet. Place the samples in different locations to prevent mixing the sand.
3. Observe the sand slides using a dissection microscope, discovery scope or hand lenses.
4. Fill out the Sand Classification Chart.
5. Answer all questions.

SAND CLASSIFICATION CHART

<table>
<thead>
<tr>
<th>Island Name:</th>
<th>Date Collected:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Sand Location</th>
<th>Sorting</th>
<th>Texture</th>
<th>Grain Shape</th>
<th>Mineral Composition</th>
<th>Maturity</th>
<th>Abiogenic or Biogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base of dunes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midway to Ocean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near swash zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Use the Barrier Island Migration and Natural Erosion Fact Sheet, the Sand Information Sheet, River and County maps and the data in the sand classification chart to answer the following questions:

1. What causes the differences in shape or roundness of the sand?

2. What factors control the types of materials/minerals found in any particular sand?

3. What was the dominant mineral type in your sand samples?

4. What was the probable source of your sand samples (what kind of rock)?

5. Are Sapelo's sands biogenic or abiogenic? Explain your answer.

6. Use your map of Georgia's rivers and trace the farthest point inland that your sand samples could have come from. Explain where the sand could have come from, where it could have entered the ocean, and how it could have gotten to Sapelo (Remember that sand may have traveled from island to island).

7. With the information gained from question 6 and the map of Georgia counties, what counties could your sand samples have passed through?

8. Explain the difference(s) in sorting, texture, grain shape, maturity and mineral composition of the sand from the base of the dunes, mid-way to the ocean and at the edge of the water.

9. Give an explanation to your answer to question #8.

CONCLUSIONS: Explain what sand is and where the sands of Sapelo probably came from (how and why). Explain how sand can be classified and how studying samples from different locations on the same beach can give you a better understanding of the forces affecting that beach.
The Loggerhead Turtle, *Caretta caretta*, is Georgia's most abundant sea turtle and often nests on Sapelo as well as Georgia's other islands. Its carapace, the upper portion of its shell, is oval and reddish brown to brown, and the plastron, the lower portion of the shell, is yellow or cream colored. The head, large in proportion to its body, is a reddish-brown with some yellow spots. A mature loggerhead weighs between 200 and 350 pounds. Every two to three years, the females crawl ashore three to five (sometimes as many as seven) times between mid-May and August to lay their eggs. Eggs are usually laid at night during high tide in the dry sand above the high tide line on the seaward side of the dunes. She digs a bulb-shaped hole with her rear flippers that is about 9 inches in diameter and 20 inches deep. She lays an average of 120 ping-pong shaped rubbery eggs, then covers them with sand using her rear flippers. It may take her 10 minutes to crawl ashore, 20 minutes to dig her nest, 20 minutes to lay her eggs, 20 minutes to cover her nest and another 10 minutes to crawl back to the water. The eggs that escape predation by raccoons and ghost crabs hatch in about two months. The loggerhead turtle moves about .5 miles per hour or 2640 feet per hour on land. She is much faster in the water. Male Loggerheads wait offshore for the females to return to the water. There they mate and the female stores the sperm for two to three years until she lays eggs again.

The baby turtles that hatch emerge from their nests at night and scramble to the ocean. Many are eaten by ghost crabs and gulls before they reach the water. Others become prey for many marine animals. Scientists estimate that only one of every 1000 eggs laid reach maturity. Those that reach maturity are thought to return to the beach where they were born to lay their eggs. It takes about 20 to 30 years for a female Loggerhead turtle to reach reproductive age and size. The lifespan of a Loggerhead is thought to be as long as man's and the females are capable of laying eggs well into their final years.
The Loggerhead turtle's favorite food is jellyfish, though they also eat shrimp, moon snails, crabs, whelks, clams, sea urchins, fish, sponges and some seaweeds and sea grasses. Large sharks are one of the adult Loggerhead few natural predators. Man, however, has become a great enemy. Although many turtles are killed each year by being caught in shrimp nets, habitat destruction is probably the major cause of the decline of the Loggerhead. Lights from beach front homes and parking lots, have also taken their toll. Females will not come ashore where there is light and the babies often become disoriented and fail to find their way to the sea.

In 1995, a total of 1028 nests were laid on Georgia's beaches. Due to high winds and waves caused by passing hurricanes, many of Georgia's beaches sustained severe erosion, as much as 50 feet of beach was lost in some areas. It is estimated that 1/3 to 1/2 of the turtle nests were lost because of this severe erosion (1995).

Dead turtles are sometimes washed ashore. This is called turtle strandings. These are studied by scientists to determine the cause of death. Many are killed by becoming caught in shrimp nets. Others are killed by boat strikes, fouling on hooks and fishing line, and by swallowing floating plastics. Two hundred and six dead turtles were recorded on Georgia's beaches in 1995. Research has indicated that only about 25% of the turtles that die offshore actually wash up onto shore, so probably many more than the recorded number actually died.

Though the Loggerhead is not currently considered an endangered species it is threatened and could become endangered if steps are not taken to ensure its survival. The Department of Natural Resources' Nongame-Endangered Wildlife Program is working to ensure the long-term survival of sea turtles on Georgia's coast. Their efforts include nest location and relocation (if necessary), nest protection, predator control, maintaining lighting ordinances on developed islands, supporting national regulations pertaining to Turtle Excluder Devices (T.E.D.s) for shrimp nets, and public education. It is hoped that through their efforts and those of all concerned citizens, the Loggerhead turtle will remain a common sight on Georgia's beaches.

### Loggerhead Sea Turtle Nests By Island for 1995

<table>
<thead>
<tr>
<th>Island</th>
<th>Nests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tybee</td>
<td>8</td>
</tr>
<tr>
<td>Williamson</td>
<td>4</td>
</tr>
<tr>
<td>Wassaw</td>
<td>77</td>
</tr>
<tr>
<td>Ossabaw</td>
<td>125</td>
</tr>
<tr>
<td>St. Catherines</td>
<td>136</td>
</tr>
<tr>
<td>Blackbeard</td>
<td>130</td>
</tr>
<tr>
<td>Sapelo</td>
<td>79</td>
</tr>
<tr>
<td>Little St. Simons</td>
<td>56</td>
</tr>
<tr>
<td>Sea Island</td>
<td>100</td>
</tr>
<tr>
<td>St. Simons</td>
<td>2</td>
</tr>
<tr>
<td>Jekyll</td>
<td>74</td>
</tr>
<tr>
<td>Little Cumberland</td>
<td>34</td>
</tr>
<tr>
<td>Cumberland</td>
<td>203</td>
</tr>
</tbody>
</table>

### Total Nests Recorded on Georgia's Islands

<table>
<thead>
<tr>
<th>Year</th>
<th>Nests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>1028</td>
</tr>
<tr>
<td>1994</td>
<td>1375</td>
</tr>
<tr>
<td>1993</td>
<td>475</td>
</tr>
<tr>
<td>1992</td>
<td>1054</td>
</tr>
<tr>
<td>1991</td>
<td>1209</td>
</tr>
<tr>
<td>1990</td>
<td>1085</td>
</tr>
<tr>
<td>1989</td>
<td>691</td>
</tr>
</tbody>
</table>

### Turtles Strandings on Georgia's Coast in 1995

- Loggerhead: 154
- Kemp's ridley: 42
- Leatherback: 3
- Green: 1
- Unidentified species: 6
LOGGERHEAD MATH

1. Approximately how many eggs can a Loggerhead turtle lay in one summer?

2. Using the formula for volume \( V = \pi r^2 h \), calculate the volume of the hole the turtle digs to lay her eggs. (remember \( D/2 = r \)).

3. Using the figures given in the Loggerhead Turtle fact sheet, calculate the percent of total time that is spent (a.) coming from the water to the nest, (b.) digging the hole, (c.) laying the eggs, (d.) filling the hole and returning to the sea.

4. The ghost crab is a major predator of sea turtle eggs and baby turtles. They are the speediest crabs along Sapelo's beaches. They travel on their toes and can reach a speed of 60 inches per second. Use the information in the fact sheet on the speed per second of the Loggerhead turtle to calculate the rate of speed per second of the ghost crab.

5. How many miles per hour can the ghost crab travel?

6. Rank the islands according to the number of nests laid in 1995 from the most nests to the least.

7. Which of Georgia's islands had the most turtle nests in 1995? Which had the least turtle nests?

8. What percentage of the total nests were laid on Sapelo?

9. Using the information provided in the fact sheet, calculate the total number of nests that could have been lost from Georgia's beaches in 1995 if only 1/3 of the nests were lost. How many eggs could have been lost? Calculate the number of nests that would have been destroyed if 1/2 were lost due to erosion. How many eggs would have been lost?

10. If turtles do return to the beach where they were born, In what year(s) could we expect to find a turtle born in 1995 laying her eggs on Sapelo?

11. Using the information on turtle strandings, calculate the percentage of the total that were Loggerhead Turtles.

12. If only 25% of dead turtles wash up onto the beach, how many Loggerhead Turtles could have died in 1995?

13. Calculate the total number of turtles (all species) that could have died in 1995.

14. Loggerhead Turtles are threatened and could become endangered if steps are not taken to ensure their survival. What can you as a citizen do to help ensure their survival?
WHO AM I?

This activity is designed to keep the interest of the students during the entire trip because they can only find out who they are by listening either to you (the teacher), the Naturalist on Sapelo or whomever is leading your group.

Before the trip, you will need to Xerox a copy of the WHO AM I? cards cut them out and glue each onto an index card or some other stiff paper. You may want to laminate them for water proofing and protection.

Tell the students that they are to pretend that they are the plant or animal that is described on a card that you will give them at Meridian Dock before they board the ferry. Stress to them that they will have to listen carefully to everything you (the teacher) or your guide says during the entire trip so that they will be able to tell you (the teacher) who they are. Instead of going on a scavenger hunt, they are going on a "scavenger listen". When they think they can identify who they are, have them bring their card to you. If they are correct you take the card. If they are incorrect, tell them to keep listening. Inform the students that they must actually hear about the organism they are before they turn in their card. (Some may know what the organism is before hearing about it during the trip.) In order to keep their attention during the entire activity, have them work together in groups of six. A group cannot win until all members have discovered WHO THEY ARE! The card groups are designed so that no group should have all their answers before reaching the beach. They will need to listen and be observant on the boat, in the marsh, the maritime forest, crossing the dune field and on the beach walk in order to hear all they need to know. You will probably want to offer some incentive or prize for the group that wins.

Answers:
1-A: Sanddollar, B: Moon snail, C: Live Oak, D: Dolphin, E: Glasswort, F: Fiddler Crab.
2-A: Sea whip, B: Ark shell, C: Bay Berry (wax Myrtle), D: Cormorant, E: Egg casing, F: Calico Crab.
3-A: Jellyfish, B: Cockle, C: Saw palmetto, D: Pelican, E: Sargassum, F: Blue Crab.
4-A: Sea Cucumber, B: Knobbed Whelk, C: Spartina, D: Gull, E: Wrack.
5-A: Polychete worm, B: Channel Whelk, C: Juncus (black needle rush), D: Sanderling/Sandpiper E: Drift wood, F: Spider crab.

WHO AM I CARD GAME (for the classroom)

To prepare the cards: Xerox both the WHO AM I CARDS and the WHO AM I PICTURES. Cut all out and glue each onto an index card. Laminate them if possible. One deck should have 30 cards, 15 with descriptions and 15 pictures. Prepare an answer key (it will be used in the game).

To play the game: Only four students should play with each deck. Shuffle the 30 cards, and pass out six cards to three of the four participants. (The fourth member of the group serves as the
scorekeeper and also verifies all pairs.) Lay the remaining cards face down in the center. The person to the left of the dealer should begin play. He/she should draw one card from the deck, he/she may either keep the card or discard it face up beside the cards that are face down. Each player may either draw a face down card or take the top, face-up card. Each player must discard a card each turn. Continue around the group, each picking up a card and discarding. If you think you have a pair, show it to the scorekeeper to verify. The object of the game is to match up as many descriptions with the correct picture as possible. Without verification by the scorekeeper, a pair does not count. The winner is the player with the most verified pairs.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>T. - I love to read books and write stories.</td>
<td>I dream of being a photographer.</td>
<td>I am the best chef in town.</td>
<td>I am a language expert.</td>
<td>I am a talented musician.</td>
</tr>
<tr>
<td>My favorite color is red.</td>
<td>I enjoy playing soccer.</td>
<td>I can cook amazing dishes.</td>
<td>I can speak five languages fluently.</td>
<td>I play the piano beautifully.</td>
</tr>
<tr>
<td>I have a big family.</td>
<td>I love to travel.</td>
<td>I have won many awards in cooking.</td>
<td>I help people in need.</td>
<td>I have won several music awards.</td>
</tr>
<tr>
<td>I have a dog named Max.</td>
<td>I love to explore new places.</td>
<td>I am a chef at a famous restaurant.</td>
<td>I teach English at a local college.</td>
<td>I am a celebrated composer.</td>
</tr>
<tr>
<td>I like to play video games.</td>
<td>I enjoy trying new cuisines.</td>
<td>I have my own cookbook.</td>
<td>I travel to different countries to learn about languages.</td>
<td>I compose music for films.</td>
</tr>
<tr>
<td>I am a huge science fiction fan.</td>
<td>I like to cook for my family.</td>
<td>I have a secret recipe for success.</td>
<td>I believe in the power of music to heal.</td>
<td>I am known for my symphonies.</td>
</tr>
</tbody>
</table>

**WHO AM I?**

I am a language expert. I can speak five languages fluently. I help people in need. I teach English at a local college. I travel to different countries to learn about languages. I believe in the power of music to heal. I am known for my symphonies. **WHO AM I?**

I am the best chef in town. I can cook amazing dishes. I have won many awards in cooking. I am a chef at a famous restaurant. I have my own cookbook. I am a celebrated composer. **WHO AM I?**

I dream of being a photographer. I enjoy playing soccer. I can cook amazing dishes. I am a chef at a famous restaurant. I have my own cookbook. I compose music for films. **WHO AM I?**

I love to read books and write stories. I dream of being a photographer. I am the best chef in town. I am a language expert. I am a talented musician. I love to travel. **WHO AM I?**

I have a big family. I enjoy trying new cuisines. I have my own cookbook. I compose music for films. I am known for my symphonies. I enjoy playing soccer. **WHO AM I?**
ACTIVITIES FOR MERIDIAN DOCK

1. Pass out previously prepared "Who Am I Cards" to the students. Remind the students that they must listen and be very attentive in order to hear or find out who or what their card is. It is always a good idea to offer some incentive for the students and groups discover what all their cards represent. DO NOT give the incentive for the first student or group to discover what all their cards represent because some of the items on the cards will not be seen until the end of the trip, some may not be seen at all.

2. Observe the zonation of the marsh. Look at the height of the *Spartina alterniflora* along the tidal creek.

3. If low tide: (a) observe and attempt to identify the types of organism growing on the pilings. (b) observe the tidal flats. Look for signs of life, such as fiddler crab activity, birds or other animals feeding in the tidal flats, a greenish film on the mud (this is algae growing on the tidal flat muds).

4. Record the tide level. Is the tide ebbing or flooding? To find out, throw a stick into the water and watch which way the water is flowing. If it flows in toward the tidal creeks, then the tide is flooding (coming in), if it flows out away from the tidal creeks, then the tide is ebbing (going out).

5. Take a water sample and record the air temperature, water temperature, pH, salinity, turbidity and dissolved oxygen of the water.

6. Collect a dock specimen sample: Go to the lowest dock and lay down on your stomach. Carefully reach under (or on the side) of the dock. Gently pull off some of the material that is growing there. Place this along with some water into a container that will not leak. You may preserve this specimen by adding a few drops of formaldehyde (this will permanently preserve the specimen) or place it in a cooler to observe back in the classroom (this will keep for a couple of days if kept cool).
SUGGESTED ACTIVITIES FOR THE BOAT

1. Students should continue to listen and observe to discover their "Who Am I" card.

2. Have the students observe any birds. Describe: the body size, shape and color, the beak size, shape and color, feet size, shape, color and location on body, shape of tail and other markings. Record the location where the bird was observed, what the bird was doing, any sounds the bird made. Compare the shape and size of the bird with the number of times it flapped its wings while flying.

3. Have each student record the route they travel and what they observe along the way. See Activity Page entitled What Do You Observe Along the Way? Have the students create a key for birds, water, marsh grass, trees, buoys, docks, light house, etc. They should mark on the map of Douboy sound where they observe these things. When they return to the classroom, they can color the map.

4. Assign a small group of students to interview the boat captain and the striker (captain's helper). Be sure to ask the captain before the boat leaves the dock if you can conduct the interview and when during the trip will it be convenient for your group to conduct the interview. See "Possible Questions To Ask The Boat Captain and Striker" for suggested questions to ask. This information should be shared with the rest of the group. Be sure to thank the captain and the striker for their time.

5. Observe any other boats passing. What type of boat was it? Which direction was it traveling? What do you think its purpose was?

6. Look for white buoys in the water along the trip. Describe what they are used for.

7. Have the students describe the docking procedure.

8. Calculate the speed that the ferry is traveling: Look for buoys in the water. Time how long it takes for the ferry to pass the buoy (from front to back). Next measure the distance from the front to the back of the ferry. How many feet per second was the ferry traveling when it passed the buoy? Calculate the speed of the ferry in miles per hour. If a nautical mile is 1.151 miles, how many nautical miles per hour was the boat traveling?
POSSIBLE QUESTIONS FOR THE BOAT CAPTAIN AND STRIKER

Questions for Captain:

1. What type of training does it take to become a boat captain?

2. What are your duties on board the boat?

3. What are your duties when not actually driving the boat?

4. For whom do you work?

5. What type of maintenance must the boat undergo? How often?

6. What are the names of the boats used to ferry passengers back and forth from Sapelo? Do they require the same maintenance?

7. How many gallons of fuel does the boat carry? _______ What type of fuel does the boat use? _______ How fast does the boat usually travel from Meridian dock to Marsh Landing Dock? _______ How many miles per gallon does the boat get? _______ Approximate cost of the fuel per gallon? _______ How far is it from Meridian dock to Marsh Landing Dock? _______ How many trips does the boat make in an average week day? _______ How many trips does the boat make during an average weekend? _______

8. Describe how the captain navigates this boat.

Questions to ask the Striker:

1. What type of training does it take to become a striker?

2. Where did you obtain this training?

3. What are your duties on the boat?

4. What are your duties when you are not working on the boat?

5. In what ways do you help the boat captain?

6. Describe your duties when the boat is docking. Describe your duties in order for the boat to leave the dock.

[Share this information with the rest of the class]

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BOAT MATH

Use the information obtained from the boat captain to calculate the following problems.

1. Figure the cost to make a one-way trip from Marsh Landing Dock to Meridian Dock.

2. Figure the cost to make one round trip from Marsh Landing Dock to Meridian Dock and back.

3. How many round trips does the boat make in an average week? (include weekends)

4. Calculate the cost of the fuel for the number of round trips made to the mainland and back in a week.

5. Calculate the number of round trips the boat would make in a year.

6. Calculate the cost of the fuel for the boat for one year.

7. Approximately how many people ride the boat each day? (You may have to ask the DNR the answer to this question if the boat captain does not know. If the information is unavailable, use 25 as the average number of passengers per day each way.)

8. Approximately how many people ride the boat in a week’s time?
   Approximately how many people would ride the boat in a year’s time?

9. If it costs $1.00 to ride the boat one way, how much revenue would be taken in by the boat in a day? (Remember to account for the total number of trips made a day.)

   In a week?

   In a year?

10. Do the passengers riding the boat to and from Sapelo pay the fuel expenses to run the boat?

    Calculate the percentage of the total cost of the fuel for the boat that is paid by the passengers.
### Directions:
Record the proper information in the space provided below. You will not record all the data at each location.

### Sapele Field Trip Data Sheet

<table>
<thead>
<tr>
<th>Flow</th>
<th>Soil pH</th>
<th>Dissolved Oxygen</th>
<th>Nitrate</th>
<th>Phosphorus</th>
<th>Nitrogen</th>
<th>Water Quality</th>
<th>Soil Color</th>
<th>Soil Texture</th>
<th>Soil Compaction</th>
<th>Weather</th>
<th>Site Condition</th>
<th>Date</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
</table>

- **Flow**: the flow of water in the field.
- **Soil pH**: the pH level of the soil.
- **Dissolved Oxygen**: the level of dissolved oxygen in the water.
- **Nitrate**: the concentration of nitrate in the soil.
- **Phosphorus**: the concentration of phosphorus in the soil.
- **Nitrogen**: the concentration of nitrogen in the soil.
- **Water Quality**: the quality of the water.
- **Soil Color**: the color of the soil.
- **Soil Texture**: the texture of the soil.
- **Soil Compaction**: the compaction of the soil.
- **Weather**: the current weather conditions.
- **Site Condition**: the condition of the site.
- **Date**: the date of the observation.
- **Time**: the time of the observation.
- **Location**: the location where the observation was made.
THE NATURE TRAIL

MATERIALS: Each group of students will need the following materials: a copy of "Some Common Plants of Sapelo," a copy of "Too Many Crabs," A Fiddler Crab Observation and Population Study for Sapelo, thermometer, soil thermometer, metal ring (from tin can), container of water, baggies, hand lens or field microscope, small bucket, hydrometer, secchi dish, dissolved O₂ kit, stopwatch or watch with a second hand and clear tape.

DIRECTIONS: As you walk along the nature trail, follow the directions, answer the questions, or conduct the activities described. This is designed to begin the trail near the "Big House".

1. As you begin walking the trail, notice the very large pine trees. These are slash pines. They have a very distinctive bark. Describe the bark.

Look around for pine cones. Collect one and other different pine cones as you travel along the nature trail. Describe the different types below:

<table>
<thead>
<tr>
<th>Pine Cone</th>
<th>Size (tip to base)</th>
<th>Location found</th>
<th>Description</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

2. SIGN #1: AMERICAN ALLIGATOR:

A. The average length of an adult alligator is ________________

B. The diet of the alligator consists of ____________________________

C. What are their nests made of? ____________________________

D. How does the alligator incubate its eggs?

3. As you pass the bridge you come into a pine thicket. Using a copy of "Some Common Plants of Sapelo," list the plants that make up the majority of the understory. ________________

4. Record the surface and soil temperature and the soil permeability of this pine thicket. Surface _____ Soil _____ Permeability _______

Collect a soil sample for analysis later.

5. Just before the grass starts on the right you should see some Cabbage palms (Sabal palmettos). The cabbage palms could eventually grow into a tree. There is another type of palm, the saw palmetto (Serenoa repens). Use your copy of "Some Common Plants of Sapelo" to locate both palms. Describe the fronds (leaves) of each: ________________

Describe the stem of each: ________________

How do you think the saw palmetto got its name?

Notice where the fronds are attached to the stem. Draw each plant (where fronds attach to stem) Saw Palmetto Cabbage (Sabal) Palm

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6. SIGN #2: RED CEDAR:
   A. The red cedar is not a true cedar. What is it?
   B. How do other animals use the red cedar? squirrels, birds, white-tail deer, song birds

7. As you continue to travel down the trail, notice the very large trees. These are Live Oaks. Describe the major understory of this area.

Note: As you come to the edge of the marsh, you will pass the edge of Pleistocene Sapelo (approx. 11,000 years old). The marsh itself and the rest of the island (seaward) are much younger (5,000 years - Holocene).

8. About halfway through the marsh measure the surface and soil temperature (of the trail) and test the permeability. Surface: ______  Soil: ______  Permeability: ______

9. SIGN #3: GREAT EGRET:
   A. Describe the color of the Great Egret's feathers, bill, and legs.
   B. Why did the number of Great Egrets decrease?

10. Look out over the marsh. Describe any differences that you notice in the height and color of the marsh grasses.

11. Draw a diagram of the marsh: Use your copy of "Some Common Plants of Sapelo" to identify (on your diagram), the locations of the following marsh plants: Spartina alterniflora (smooth cordgrass), Spartina patens (salt meadow cordgrass), Borrichia frutescens (sea-oxeye daisy), Juncus roemerianus (black needle rush), Salicornia virginica (glasswort), Batis maritima (saltwort) and Distichlis spicata (salt grass).

12. Go onto the bridge to the observation deck. Look for periwinkle snails on the blades of the Spartina alterniflora. These snails have a built-in time clock and move up and down the blades of grass with the tides. If the tide is coming in (flooding), they move up to the top of the grass blades. If the tide is going out (ebbing), they move down the grass blades. According to the location of the periwinkle snails, what is the position of the tides? Look at the grass blades carefully. The snails do not eat the grass.
THE NATURE TRAIL

What would they eat? ______________________________________________________________________. (Observing a blade of grass with a hand lens or field microscope will help you to answer this question.)

13. Sign #4: Saltwort:

A. Why is saltwort usually one of the first plants to pioneer (appear) in the marsh and salt flats or salt pans? ______________________________________________________________________

B. List several of the special adaptations of the saltwort that enable it to live in this environment. ______________________________________________________________________

14. Sign #5: Fiddler Crab:

A. Describe how you can tell the difference between a male and a female fiddler crab. ______________________________________________________________________

B. Explain how the fiddler crab got its name. ______________________________________________________________________

15. With the other students in your group, conduct the activity "Too Many Crabs" A Fiddler Crab Observation and Population Study For Sapelo.

16. Sign #6: Salt Barrens (Salt Pan, the locals call this area the "Salt Pond"):

A. Describe how these salt pans form. ______________________________________________________________________

B. Look around the salt pan. What different evidences of animals do you see in or near the salt pan? __________. Describe and draw each type in the chart below. (You may use this chart to record evidence of animals from other locations as well.

<table>
<thead>
<tr>
<th>Animal Evidence</th>
<th>Location observed</th>
<th>Description</th>
<th>Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trails</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burrows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scat</td>
<td></td>
<td>(Break open and describe contents)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. Notice the height of the Spartina alterniflora in the salt pan. Compare this height to the height of the same plant in the lower marsh (see question 10). If these are the same plant,
THE NATURE TRAIL

why is there such a difference in their height? ________________________________

18. Carefully measure the surface temperature and soil temperature of the marsh. You will have to lie down on the deck. Please do not walk in the marsh. Surface: _____ Soil: ______
Collect a small soil sample of the marsh mud to take back to the classroom. Once back in the classroom, dry the marsh mud sample and observe its composition. Test the permeability of the marsh mud.

19. Return to the trail and find **Sign #7: Sea Oxeye Daisy:**
A. On what part of the marsh does Sea Oxeye Daisy grow? ________________________________
B. How does it reproduce? ________________________________

20. **Sign #8: Salt Marsh:**
Notice that grass of the same kind is found at different heights in the salt marsh. *Spartina alterniflora*, the most common plant in the salt marsh, grows only as high as high tide. Therefore, if it grows near a tidal creek or river it will grow much taller than it will if it is farther back in the marsh or on a salt pan where the water is very shallow.
A. How do tides affect marshes? ________________________________
B. When is the mud deposited in the marsh? ________________________________

21. **Sign #9: Clapper rail:**
Describe the clapper rail. ________________________________
You probably will not see one but if you listen carefully to the sounds of the marsh, you may hear one.

22. **Sign #10: Saltmarsh Cordgrass:**
*Spartina alterniflora* provides cover or shelter for many animals. It holds the marsh together with its spreading roots. When the plants die, they become detritus, a major food source for many marsh and ocean animals.

23. **Sign #11: Great Blue Heron:**
A. Why are Great Blue Herons often seen standing motionless? ________________________________
B. Where and how do Great Blue Herons nest? ________________________________

24. The creek is called Barn Creek: Collect a sample of water in a bucket. Quickly insert a thermometer and measure the temperature of the water: _________ . If a hydrometer is available determine the salinity: _________ . Use a Secchi dish to determine the turbidity: _________ . If materials are available, determine the dissolved oxygen content: _________ .

25. Next, determine the direction and rate of flow of Barn Creek: From the beginning of the bridge (before you cross it) to the big red cedar tree behind the Raccoon sign is 100 feet. Have one student stand at the beginning of the bridge and another student with a stop watch or watch with a second hand stand by the big cedar tree. The student at the beginning of the bridge should drop a stick or pine cone into the water and motion for the student by the cedar tree to start timing. Record the number of seconds it took for the stick or pine cone to reach the cedar tree. (Reverse this if the water is flowing towards the bridge). Calculate the speed of the water by dividing the number of seconds into 100 feet. The speed of water flow is expressed in feet per second. The speed of water flow in Barn Creek was: _______.

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THE NATURE TRAIL

Was the water ebbing or flooding? ________________. (If the water is flowing towards the bridge, the tide is coming in. If it is flowing towards the cedar tree, the tide is going out.)

26. Once you cross the Barn Creek bridge, you come into a mostly Red Cedar forest. The understory here is mainly Youpon Holly (See "Some Common Plants of Sapelo." The Indians used to make a tea from the Youpon Holly that they drank before going into battle. The tea would make them throw-up which was supposed to purge their bodies and make them better in battle. This is how it got its scientific name: Ilex vomitoria. Find a Youpon Holly and describe it: ____________________________

27. **Sign #12: Raccoon:**
   A. What do raccoons eat? ____________________________
   B. When do they usually eat? ____________________________
   C. Why do you think they eat when they do?

28. Record the surface and soil temperature here: Surface: _____ Soil: _____
   Is the temperature different here than out on the marsh? _____ Can you explain this?

29. **Sign #13: Saw Palmetto:**
   A. How does the Saw Palmetto get its name? ____________________________

30. **Sign #14: Southern Magnolia:**
   A. Describe the seeds of the Southern Magnolia. ____________________________

31. Continue along the trail. You will enter another mostly pine thicket with one or two live oak trees and a few red cedars with a youpon understory. Pay close attention to the height of the understory. Next you will cross a foot bridge over a slough (wet during the rainy season and dry during non-rainy times). Notice the height of the youpon understory under the large live oak tree on the left after the foot bridge. Compare the height of these youpons with the height of the understory under the pines you just passed through. What could cause this difference? ____________________________

32. **Sign #15: Live Oak:**
   A. How high can a Live Oak grow? _____ B. How far do the branches spread? _____
   C. Wood from the Live Oak was commonly used for ____________________________.
   D. Resurrection fern is often found growing on the tops of the branches of Live Oak trees. It is green when there is ample moisture, but turns brown and appears to be dead when there is little or no moisture. Locate the resurrection fern. Describe its condition.

   E. Sometimes a pinkish red lichen (a symbiotic growth of algae and fungus) called Blood Lichen can be seen growing on the trunk and limbs of the Live Oak tree. Locate and describe the Blood Lichen you observe. ____________________________

   F. Pick up a handful of soil. Observe it under a hand lens or field microscope if one is available. Describe the soil: ____________________________

33. Continue walking along the trail. The small hills you cross are actually old sand dunes. Stop at the branch that goes across the path and examine the resurrection fern, lichen, and Spanish Moss.

34. **Sign #16: Spanish Moss:**
   A. What family is Spanish Moss a member of? ____________________________
   B. Spanish Moss is an epiphyte. What does that mean? ____________________________

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THE NATURE TRAIL

C. Where does the Spanish Moss get its nourishment? __________________________

D. Collect a small sample of Spanish Moss and take it back to the classroom and examine it under a microscope. Describe its stem and leaves. If you have a field microscope or hand lens, examine and describe it here. __________________________

35. Continue traveling along the trail. Cross another old worn dune ridge. When you come to an area with several benches under a very large Live Oak tree, sit down, close your eyes and quietly listen to the sounds of the forest for a few minutes. Describe what you hear. __________________________

When you return to the classroom, write a poem entitled: "The Sounds of Sapelo's Live Oak Forest."

36. Record the surface and soil temperature and permeability of the soil in this area.
   Surface: ________ Soil: ________ Permeability: ________

37. You will next cross some ancient dunes. Remember that all dunes are fragile areas and stay on the footpath.
   Sign #17: Eastern Diamondback Rattlesnake:
   A. Describe the Eastern Diamondback Rattlesnake. __________________________
   B. What does it like to eat? __________________________
   C. What habitats does it prefer? __________________________

38. Sign #18: White-tail Deer:
   A. Describe the diet of the white-tail deer. __________________________
   B. How does it escape from predators? __________________________

39. Sign #19: Sabal Palmetto:
   A. How did the Sabal Palm get its common name, the Cabbage Palm? __________________________

40. As you continue walking along the trail look to your left, if the season is right, you will probably see a plant called Dog Fennel. (Use your copy of "Some Common Plants of Sapelo" to identify it) Some locals use crushed Dog Fennel to deter fleas. Describe the Dog Fennel if you are able to locate it. __________________________
   Notice the understory in the next area you cross.

41. You will now come to a foot bridge over some secondary dunes. Without disturbing the dunes, record the surface and soil temperature and the permeability of these dunes.
   Surface: ________ Soil: ________ Permeability ________
   Describe how the soil here (sand) is different from the soil in the forest. __________________________

42. Climb the tower to the left. Use your copy of "Some Common Plants on Sapelo" to list the types of vegetation on these secondary dunes. __________________________
   Look for signs of animals. If you locate any, describe them in the chart in question #16.

43. Sign #20: Wax Myrtle:
   A. Break off a few leaves of the Wax Myrtle and crush them. Then smell the leaves.
   Describe the smell. __________________________
   The Wax Myrtle is also called the Bayberry. Can you explain this? __________________________
   What are the leaves of the Wax Myrtle often used for? __________________________

44. As you walk on, notice the bunches of grass on either side of the path. Based on the following rhyme, "Sedges have edges, Rushes are round, Grass is flat, that's that," are these grasses sedges, rushes, or grasses? __________________________
THE NATURE TRAIL

CONTINUE WALKING: You will go up another old dune onto another foot path.

45. **Sign #21: Longleaf Pine:**
   A. How did the Longleaf Pine get its name? ________________________________
   B. What did Native Americans use the needles for?
   C. How are these cones different from the other cones you have seen along this trail? _____
   Record information about these pine cones in your chart in question #1.

46. **Sign #22: Spanish Bayonet (Yucca):**
   A. Describe the Spanish Bayonet. __________________________________________
   B. How do you think it got its name? ______________________________________

47. You are now crossing a mature Interdune Meadow with shrubs (Wax Myrtle) and low growing plants. A. Why do you think the plants and vines grow so low to the ground?
   ________________________________________________________________
   B. Notice that the Wax Myrtle trees grow as if they are leaning toward the land. This is called salt pruning. Explain why you think this happens. ________________________________

48. Using your copy of "Some Common Plants of Sapelo," list several of the low-growing plants you see in this interdune meadow. _______________________________________
   Describe the difference in the size and height of these plants compared to those you observed from the tower. _______________________________________

49. **Sign #23: Turkey Vulture:**
   A. How can you identify a Turkey Vulture? _________________________________
   B. Turkey Vultures eat carrion. What is carrion? ___________________________

50. **Sign #24: Sea Oats:**
   A. Why are Sea Oats important? __________________________________________
   B. Explain the two ways in which Sea Oats grow. ___________________________

51. **Sign #25: Brown Pelican:**
   A. Why did the Brown Pelican become endangered? ________________________

52. **Sign #26: Loggerhead Turtle:**
   A. Describe the Loggerhead Turtle. _______________________________________
   B. What has caused its decline in numbers? ________________________________

53. **Sign #27: Laughing Gull:**
   A. How can you recognize a Laughing Gull? _________________________________
   B. Why do they like to follow fishing boats? _______________________________

54. When you reach the beach: Stand at the base of the dunes, bend over, lick your little finger and lay that damp finger in the sand at your feet, then stand up. Look towards the ocean. Mentally divide the distance between you and the ocean into four parts. Walk one-fourth of the distance to the ocean, lick your ring finger and lay that damp finger in the sand at your feet. Walk to one-half your original distance to the ocean and repeat the process with your middle finger. Continue walking toward the ocean, collecting sand on your remaining fingers as described above. The sand sample on your thumb should be taken at the water's edge. Place the sand samples (from each finger) in order from the dunes to the ocean on a strip of clear tape. Examine the samples. Compare the size of the sand grains and the composition of the sand samples on your strip of tape. ________________________________

55. Go back to the dune area and await instructions from your teacher or guide.
"TOO MANY CRABS"
A FIDDLER CRAB OBSERVATION AND POPULATION STUDY FOR SAPELO

PART I:
1. At the marsh observation deck along the nature trail have the students line up along the bank, the walkway and along the observation deck (see picture).

2. Have each student select a section of the marsh or salt pan about one foot square where the ground can be seen clearly.
3. This entire area is approximately 300 feet by 500 feet.
4. Each student should count the number of fiddler crab burrows they see within their square foot section. Count the number of fiddler crab burrows in your square foot section: ________
5. Tally the number of burrows each class member counted and divide the number by the number of students participating. This is the average number of fiddler crab burrows for the area tested. Average # of Burrows: ________
6. Calculate the number of square feet in the entire area. (Use the figures in #3). ________
7. Use the answers to step 5 and step 6 to calculate an estimate of the number of fiddler crabs in the entire marsh area. Total estimate of Fiddlers in this area: ________

PART II:

Choose an area either at the marsh along the observation deck or at the tidal flats at Marsh Landing dock and answer the following questions.

1. How many fiddler crab burrows do you see in a one foot square area? ________
2. Describe what the crabs are doing.

3. Males have one large and one small claw while the females have two small claws. How many females do you see in your one square foot area? ______ How many males do you see? ______
4. Is there any observable difference(s) in the males and females other than their claws? If so describe.

5. Observe what the males do with their large claw. Describe what you see.

   Why do you think they are doing this?

6. In your one foot square quadrant, you will likely see two sizes of dirt balls. One is a "housekeeping ball" that the fiddler throws out of its burrow at low tide. The other is a "food ball," formed as the fiddler extracts food from the mud or sand. Which size is the "housekeeping ball?" Why do you think so?

6. Which is the "food ball"? Why do you think so?

7. How many of the male crabs that you observed had a right-handed large claw?

8. How many of the males had a left-handed large claw?

9. If a male fiddler loses his large claw, he grows another one on the other appendage. According to your observations, do you think all crabs begin life with the large claw on the same appendage? What makes you think so?

10. Observe how the crab eats. Describe what it does with the sand or mud.

11. After observing the fiddler crabs, can you see how they got their name? Explain your answer.

12. Describe the eyes of the fiddler crab. Where are they located? How does this adaptation help the fiddler?

13. What happens when a predator approaches? If you do not observe this, make a prediction.

   Who (the male or the female) is the first to hide in its burrow? Which is the first to return after the danger is past?

14. How does the fiddler's burrow serve him?

15. Watch for ceremonial fights between two males. If observed, describe what happens.

   Do they appear to be fighting over a female or a territory? Explain.

16. Describe how they fight.

   Do they appear to hurt each other? Explain. Which one won? Why do you think this?
### Common Plants of Sapelo

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscadine Grape (Vitis rotundifolia)</td>
<td><img src="image1" alt="Muscadine Grape" /></td>
</tr>
<tr>
<td>Southern Magnolia (Magnolia)</td>
<td><img src="image2" alt="Southern Magnolia" /></td>
</tr>
<tr>
<td>Red Cedar (Juniperus virginiana)</td>
<td><img src="image3" alt="Red Cedar" /></td>
</tr>
<tr>
<td>Virginia Creeper (Parthenocissus)</td>
<td><img src="image4" alt="Virginia Creeper" /></td>
</tr>
<tr>
<td>Wax Myrtle (Myrica cerifera)</td>
<td><img src="image5" alt="Wax Myrtle" /></td>
</tr>
<tr>
<td>Cabbage Palm (Sabal palmetto)</td>
<td><img src="image6" alt="Cabbage Palm" /></td>
</tr>
<tr>
<td>Saw Palmetto (Serenoa repens)</td>
<td><img src="image7" alt="Saw Palmetto" /></td>
</tr>
<tr>
<td>Yousoum Holly (Ilex vomitaria)</td>
<td><img src="image8" alt="Yousoum Holly" /></td>
</tr>
<tr>
<td>Live Oak (Quercus virginiana)</td>
<td><img src="image9" alt="Live Oak" /></td>
</tr>
<tr>
<td>Long-leaf Pine (Pinus palustris)</td>
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<td>Longleaf Pine (Pinus loblolia)</td>
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<tr>
<td>Slash Pine (Pinus elliottii)</td>
<td><img src="image12" alt="Slash Pine" /></td>
</tr>
<tr>
<td>Russian Thistle</td>
<td>Fiddlehead Morning Glory</td>
</tr>
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<tr>
<td>(Salsola kali)</td>
<td>(Ipomoea stolonifera)</td>
</tr>
<tr>
<td>Bitter Panic Grass</td>
<td>Railroad Vine</td>
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<tr>
<td>(Panicum amarum)</td>
<td>(Ipomoea purpurea)</td>
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<tr>
<td>Sandspur (Convolvulus pedunculatus)</td>
<td>Pennywort (Dollar Weed)</td>
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<td>(Hyptis pectinata)</td>
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<td>Pricklypear Cactus</td>
<td>Beach Cotton (Crotalaria)</td>
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<tr>
<td>(Opuntia humifusa)</td>
<td>(Crotalaria juncea)</td>
</tr>
</tbody>
</table>
TRACKS, TRAILS AND BURROWS

OBJECTIVE: To investigate the evidence left behind by animals.

MATERIALS: plaster of paris
             hair spray
             spoon
             notebook/pencil
             water
             trowel, knife or stick
             ruler
             old toothbrush
             camera (optional)
             mixing container (plastic bowl or tin can)

BACKGROUND INFORMATION:

Animals and sometimes plants living in coastal environments often leave tracks, trails, and other evidence of their presence even though they may be absent when the area is viewed. Other pertinent signs include scat (fecal remains or droppings), food litter, gnawings, scratchings, rubbings, nests and burrows. This indirect evidence is important because the correlation of these track, trails, burrows and other signs of the organisms that made them allow the natural scientist to interpret or infer a great deal about the area being studied. Although the organisms may not be present, careful observation of what they leave behind gives evidence to what the animals were doing, where they went or how large they were. Geologically they enable interpretation of what otherwise would be strange markings in the ancient geologic record.

Once you become aware of the tracks and other evidences an animal leaves behind, you will be surprised at how many animals may visit a seemingly barren area. Whether walking, running, crawling or hopping, animals leave a story of their activities in the tracks they leave behind by their claws, feet and tails. When you learn to "read " tracks and trails, you may want to become a "track detective" and figure out track riddles as you walk along the marsh, maritime forest, mud flats, dunes and beach.

PROCEDURE:
Before doing this activity on Sapelo, you will probably want to try it in the classroom. Look for animal signs in your school yard and practice mixing the plaster.

1. As you walk through the various habitats on Sapelo, watch for any sign of an animal. When you find one, record its location, describe its overall pattern, and the direction it is heading. Measure the length and width of the track and the distance between the tracks (stride) if more than one is available. Look for signs of tail or wing marks and record these. If you have a camera, take a picture. Remember to place a ruler or some other marker beside the track to indicate its size.

   (Make charts like the one to the right.)

   Date _______ Time _______ Location _______
   Direction heading _______ Length ______ Width _______
   Stride _______ Drawing:
   Description of overall pattern:

   Other marks present:

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2. Make a plaster cast of the track:
   A. First spray the track with hairspray. This will set the sand.
   B. Mix plaster of paris and water in your mixing container until it is the consistency of a thick pancake batter. (The mixture will begin to harden quickly, so work fast. If too thick, add more water. If too thin, quickly add more plaster).
   C. Pour the mixture into the track being sure to cover all parts of the track.
   D. Allow the plaster of paris to harden. While the plaster is drying, attempt to follow the trail of the animal but be sure not to damage the dunes or any fragile plants.
   E. When the plaster of paris is hard, gently remove it with a trowel, knife or fingernail. This is a reverse mold of the track.
   F. Clean off the dirt or sand by washing it or gently brushing it with an old toothbrush.
   G. Scratch the date and location on the back of your plaster print.
3. Take your reverse mold back to the classroom and using a cardboard coke flat, cut and tape a box a little larger than your mold. Cover the entire inside of this box with vaseline. Mix more plaster of paris and pour it into the cardboard box. Place your reverse mold into the plaster mixture and smooth the wet plaster around your mold. This will build a plaster frame around your mold. When this hardens, spread the entire surface with more vasoline. Mix more plaster of paris and pour it on top of your mold. When this hardens, carefully separate the two halves. You now have a cast that looks just like the track you found.

OBSERVATIONS: Using your cast and the information you recorded when you found the print answer the following questions.

1. What do you think the animal that made the track was doing? Give evidence to support your answer.
2. Was the animal hopping, running, walking or just standing? Give evidence to support your answer.
3. Was the animal feeding? Give evidence to support your answer. (Consider where the track was and any surrounding evidence such as beak marks or food remains)
4. Could the animal have been hiding from a predator? Give evidence to support your answer.
5. If you followed a trail of tracks, where was the animal going or where did it appear to be going? Give evidence to support your answer.
6. Why do you think the animal was where it was when it made the track? Support your answer.
7. Using reference books in the library or from your teacher, try to find out what kind of animal made the track.

CONCLUSION: Explain how, even though an animal cannot be seen, observing the tracks and other evidences left behind by animals can give scientists a better understanding of an area and what goes on there.

Extensions:
1. Write a story about the animal(s) that made the track explaining what it was doing and what could have happened to it.
ANIMAL TRACKS YOU MIGHT SEE ON SAPPLEO

Deer
Raccoon
Dog

Opossum
Mink
Gull

Heron, Egret
Sandpiper
Rabbit

Turkey
Alligator
Fiddler Crab Burrow
MEASURING WAVELENGTH

PURPOSE: To measure the wavelength of waves along the coast of Sapelo Island.

MATERIALS: Waves Fact Sheet
Two tall stakes or poles
Watch with a second hand
4 meters of rope
Meter stick

BACKGROUND INFORMATION: To figure wavelength you need to measure two aspects of wave motion: the speed the wave is moving through the water in meters per second and the wave period. The wave period is the time in seconds it takes for two successive wave crests to pass a fixed point. Wavelength = Velocity $\times$ period

(cm) = (cm/second) $\times$ (seconds)

PROCEDURE:

1. Read the fact sheet on waves.
2. Tie the rope to the two poles so that they are three meters apart.
3. With a student holding each pole, place the poles in the water so that one pole is three meters closer to the shore than the other. The rope should be taut, do not stretch it tight, and approximately at the water level.

4. Record the time it takes for one wave crest to travel from the first pole (the one farthest out in the water) to the pole closer to shore.
5. Repeat step 4, four more times and record the information in the data table #1.
6. Compute the average velocity by adding the 5 numbers and dividing by 5, express this in cm per second. (You will have to convert the three meters to centimeters).
7. Next, record the time between crests. Measure the time one crest hits a stake until the next crest hits the same stake. Do this four more times and record your information in data table 
2. Calculate the average wave period in seconds.
8. Calculate the wavelength: Wavelength = Velocity x Period.

DATA TABLE # 1: Velocity

<table>
<thead>
<tr>
<th>TRIAL</th>
<th>SECONDS</th>
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<tbody>
<tr>
<td>1</td>
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<td>3</td>
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<td>4</td>
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<td>5</td>
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<tr>
<td>Average</td>
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</tbody>
</table>

DATA TABLE # 2: Period

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<tr>
<th>TRIAL</th>
<th>SECONDS</th>
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<tbody>
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<td>2</td>
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<td>4</td>
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<td>5</td>
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<tr>
<td>Average</td>
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</tbody>
</table>

Average Velocity = _______ centimeters / second
Average Period = _______ seconds

Wavelength = ___________________________ centimeters

CONCLUSION: Describe the wavelength of the waves off the shore of Sapelo Island.
LONGSHORE CURRENTS

OBJECTIVE: To investigate the affect of longshore currents and wave action on the movement of sand along Sapelo Island.

MATERIALS: several whole pinecones
several pinecones cut into pieces
100 foot measuring tape
stopwatch or watch with a second hand
nine student helpers

BACKGROUND INFORMATION:
Barrier Islands are in a constant state of change. The action of waves and longshore currents constantly work and rework the sand along the shoreline. Waves remove sand from the beach and deposit it in sandbars a short distance offshore and later return the sand from the sandbars to the beach. The longshore currents pick up the sand and carry it southward to another part of the island or to an adjacent island.

PROCEDURE:
Before going to the beach:
1. Collect some pinecones. You will need several whole ones and several that have been cut into small pieces.
2. Assign student helpers to the following jobs:
   A. Two students mark the beach: They need to mark the starting and stopping points on the beach. Marks should be about 3 feet long and extend from the water line toward the dunes. The marks should be 100 feet apart.
   B. Two students will deposite whole pinecones into the water.
   C. One student will indicate when to start timing.
   D. One student will indicate when to stop timing.
   E. One student will serve as the timer.
   F. One student will record all information.
   G. One student will signal to the others when to start the activity.

At the beach:
1. The students responsible for marking the beach should do so as follows: With your foot, mark a long line about three to four feet long that extends perpendicular to the ocean from the waterline toward the dunes. This will be your starting point for this activity. Place the beginning of measuring tape on this line and measure a distance of 100 feet down the beach (to the south). Make another three-foot to four-foot mark perpendicular to the ocean. This will be your stopping point.
2. Have one student stand at the starting point, when the pinecones pass in front of him/her, he/she tells the timer to start timing.
3. Have one student stand at the stopping point. This student should tell the timer when the pine cone passes this point (stopping time).
4. The timer should stand between the beginning and stopping points so he/she can see and hear both students.
5. The record keeper should record the beginning and ending times and calculate the difference in time.

6. Have one student carry a pine cone into the water at least 20 feet or so from shore (beyond the breakers if possible). This student may need to walk part way and throw the pine cone. At the same time another student should carry a pine cone about three or four feet into the breakers. **The student assigned to start the activity should tell the students when to release the pinecones.**

7. Starting time is the exact time the pinecones pass the starting point. Stopping time is the exact time the pinecones pass the 100 foot mark.

8. Observe the movement of the pinecones in each location and calculate the rate of longshore transport.

9. **NEXT:** Have a student release the cut up pinecone pieces about three to four feet into the breakers. Release them at the original starting point and record the release time and the time the last piece washes on shore. Observe their movement and plot the positions that each land on the beach. Measure the distance that the last piece travels, count and plot the locations of the pieces. (see observations question # 4)
OBSERVATIONS:

DATA TABLE:

<table>
<thead>
<tr>
<th></th>
<th>PINE CONE BEYOND BREAKERS</th>
<th>PINE CONE WITHIN BREAKERS</th>
<th>PINE CONE PIECES</th>
</tr>
</thead>
<tbody>
<tr>
<td>START TIME</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>END TIME</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>DIFFERENCE IN TIME</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>DISTANCE TRAVELED</td>
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</tbody>
</table>

ANSWER THE FOLLOWING QUESTIONS:

1. Describe the movement of the two pinecones:
   Beyond breakers:

   Within breakers:

   What probably caused the difference in movement?

2. Calculate the rate of longshore transport for both pinecones. (Use the information in your data table)  
   Speed of transport = \[ \frac{\text{difference in time}}{\text{distance traveled}} \]

3. Describe the movement of the pinecone pieces.

4. In the space below, plot the locations and distances that the pinecone pieces landed on the beach.

5. How far from the starting point did the majority of the pinecone pieces land?

6. What was the least distance traveled by a piece of pinecone?
   What was the greatest distance traveled by a piece of pinecone?

CONCLUSION: From what you have observed in this activity and assuming that the pinecones and pinecone pieces represent grains of sand, explain the effect of longshore currents and wave action on the movement of sand on Sapelo Island.

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BEACH PROCESSES

OBJECTIVE: To observe, measure and sample sediment beds to interpret the erosional and depositional history of the beach.

MATERIALS: Shovel Cheese cloth Clear Polyurethane Varnish small paint brush ruler meter stick or yardstick trowel (can use the ruler) 4 nails Clear polyurethane spray paint

BACKGROUND: Beaches are constantly undergoing erosion and deposition (accretion). One of the best ways to view a record of this erosion and deposition process is trenching. By digging a trench perpendicular to the dunes (down the beach face) and observing the layering patterns, scientists can tell a great deal about what has happened to the beach. Thick beds usually represent periods of deposition. Thick dark layers or beds (the dark layers are the heavy minerals) usually represent storms because it takes a greater force to make large layers of heavier minerals. The shape of the layering gives clues to the shape of the beach at the time of deposition. The curve of the various layers of sand is an indication of whether the beach was undergoing accretion or erosion (see figure a). If the layers are parallel and continuous, the area was probably underwater away from the influence of waves (see figure c). If the layering is wavy the sand was probably deposited as ripple marks and the water was either flowing back and forth or in only one direction (see figure b). By observing how the layers are formed, scientists can also tell which direction the water was flowing. A lot of cross-bedding usually represents changes in direction of flow of the water or wind. To a trained geologist, the layering of sediments reads like the pages of a book. They are able to study the layering and determine what may have been happening when they were laid down.

Figure a:

Figure b:
PROCEDURE:
1. Using a shovel, dig a trench 1 to 2 meters long and 1/2 to 1 meter wide (can be smaller, but must be large enough to easily see the layering patterns) down the beach, perpendicular to the dunes and ocean. Be careful not to dig the trench too close to the dunes.
2. Use a trowel, the shovel blade or meter stick to smooth the surface.
3. Observe the layering pattern and record your observations.
4. Put all the sand back into the trench!

OBSERVATIONS:
1. Draw the layering pattern of the sand along the walls of the trench. Indicate the heavy minerals (the dark bands) with dark dots.
2. Measure the distance between each layer and record this on your drawing.
3. Prepare a cross-section to take back to the classroom: Spray the area you want with the clear polyurethane. Place a piece of cheese cloth (double thickness) over this area and secure it with nails. Paint the cheese cloth with clear polyurethane varnish. Put on several layers of varnish. Let the varnish dry, then peel off the cheese cloth. When completely dry you have a preserved specimen of your cross-section to take back to your classroom.
4. Using the background information, the diagrams, your drawings and the preserved cross-section, interpret what was happening when these layers were deposited. Begin your description with the bottom layer and work upward. Tell if you think there was deposition or erosion and why. Tell when you think there was a big storm and why. Tell which direction the water or wind was flowing. Were the layers formed on the upper beach away from the water, in the intertidal zone where water flows back and forth, or in deeper water. Be sure to support all your answers.

CONCLUSION:
Explain how scientists can tell the erosional and depositional history of a beach by observing the layers in a trench.
BEACH SEINE ACTIVITY

OBJECTIVE: To identify organisms that live in the shallow water offshore of Sapelo.

MATERIALS: Beach seine
bucket
sea water
field guides
collecting jars or baggies

BACKGROUND: A beach seine is designed to be pulled by two or more people (depending on the size of the seine) through the shallow water just offshore from the beach. The seine consists of a mesh net attached to two poles. A beach seine is used to collect organisms that swim in the shallow water.

PROCEDURE:
1. With one student at each end, unravel the net until both poles are exposed.
2. With a student holding each pole, enter the water perpendicular to the beach. The student in the lead should walk into the water as far as he/she can safely go (no deeper than shoulders), then turn and walk up the beach. When the lead student is approximately parallel to the student holding the other end of the seine, they both should begin walking toward the shore. The poles should be dragged along the bottom with the bottom of the pole a little in advance of the top.
3. When the seine is dragged onto the shore, other students may help to gather and count the different specimens collected.
4. Place one of each type of organism caught in the seine in a bucket of sea water, then quickly return the rest to the sea.
5. Observe the organisms collected and record this information in your data table.
6. Discuss their special adaptations.
7. Return the organisms that are still alive to the ocean. Those that died may be preserved and taken back to the classroom.
8. Clean the net and roll it up on the poles.

OBSERVATIONS:
1. List all organisms collected in your data table.
2. Use field guides to identify the organisms collected.
3. How many different organisms did you collect?
4. How large was the largest organism you collected?
5. Why do you think large organisms were not caught in the seine?
6. Discuss some of the special adaptations of the organisms you collected.

CONCLUSION: Discuss the types of organisms that live in the shallow waters off shore from Sapelo.
<table>
<thead>
<tr>
<th>Name</th>
<th># Collected</th>
<th>Description</th>
<th>Sketch</th>
<th>Adaptations</th>
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BEACHCOMBING

OBJECTIVE: To collect and identify organisms that live or are washed up on the beach.

MATERIALS: bucket or baggie
             copy of Beachcombers Guide to Sapelo

BACKGROUND: The beach is a treasure chest of interesting things to examine and or collect. The treasures of the beach are constantly changing. Anything that is or was in the ocean may be washed up onto the beach by the waves and tides. Items are brought to the beach at high tide and may be swept off the beach again with the next high tide. Some animals like sanddollars, whelks, clams etc. live buried under the sand. When these organisms die, their shells wash up onto the beach. Some animals, like crabs, molt or shed their outer skeleton as they grow. The crab molts are often found on the beach. Pieces of wood (driftwood) are plentiful on the beach. This driftwood ranges in size from very small to large pieces. Often the driftwood will be riddled with holes. These holes are mostly caused by an organism called a shipworm, that gets into the wood while it is in the water and uses the wood as a food source, leaving the wood full of holes. Several organisms like the knobbed and channel whelks, oyster drills, moon snails, banded tulips and even the skates lay their eggs in special cases. These cases are also often found wash up onto the beach. Very common on the beach yet often overlooked are the signs of worms. Wrack, dead decaying marsh grasses, is brought to the beach by the waves and tides and a line of this plant debris marks the high tide line. Several small animals like to live and/or hide in this wrack.

PROCEDURE: The best time for beachcombing is when the tide is ebbing (going out).

1. Divide the students into small groups (this can be done individually).
2. Give each student or group of students a collecting bucket or large plastic baggie.
3. Give instructions on how much time the students have to collect their treasures.
4. After the students have collected their treasures, have them meet back in a large group and show what they have found to the entire group. If you have a guide or naturalist along, he/she can explain to the student what they have found. If you do not have a guide or naturalist, use the Beachcombing Guide to Sapelo and other reference materials to help the students identify their treasures.
5. Each student should fill in the data table for the organisms they collected.
6. It is all right to collect shells and driftwood, but please do not take live organisms from the beach. Take only what you will use.

OBSERVATIONS: Use the treasures you collected, the Beachcombers Guide to Sapelo and other reference materials to fill in the data table.

CONCLUSION: In your own words, write a short paragraph about the different treasures you found on Sapelo. Include a discussion of where they were found, how they probably got to the beach, and how the item was used by the animal or plant that it came from.
Beachcombing Data Table:

<table>
<thead>
<tr>
<th>Drawing</th>
<th>Is this a plant or an animal?</th>
<th>To what phylum does it belong?</th>
<th>List special adaptations</th>
<th>Name the organism</th>
</tr>
</thead>
<tbody>
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Common Gastropods

Beachcombers Guide to Sapelo
<table>
<thead>
<tr>
<th>Angle Wing</th>
<th>Quahog Clam</th>
<th>Blood Ark</th>
<th>Giant Atlantic Cockle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallen Angle Wing</td>
<td>Jackknife Razor Clam</td>
<td>Transverse Ark</td>
<td>Ribbed Mussel</td>
</tr>
<tr>
<td>Channeled Duck Clam</td>
<td>Cross-barred Venus</td>
<td>Ponderous Ark</td>
<td>Penn Shell</td>
</tr>
<tr>
<td>Coquina</td>
<td>Atlantic Surf Clam</td>
<td>Kittens Paw (uncommon)</td>
<td>Oyster</td>
</tr>
<tr>
<td>Stout Tegelus</td>
<td>Tellin</td>
<td>Crosshatched Lurine</td>
<td>Disk Dolina</td>
</tr>
</tbody>
</table>
Spider Crab

Ghost Crab

Calico Crab

Lady Crab

Horseshoe Crab (not really a crab)

Blue Crab

Speckled Crab

Purse Crab

"Common Crabs and Crab Molts"

BEACHCOMBERS GUIDE TO SAPELO
<table>
<thead>
<tr>
<th>Banded Tulip</th>
<th>Knobbed Whelk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oyster Drill</td>
<td>Channeled Whelk</td>
</tr>
<tr>
<td>Moon Snail</td>
<td>Lightning Whelk</td>
</tr>
<tr>
<td>Skate</td>
<td>Pear Whelk</td>
</tr>
</tbody>
</table>

**BEACHCOMBERS GUIDE TO SAPELO**

"Egg Cases"
<table>
<thead>
<tr>
<th>Ghost Shrimp Burrow</th>
<th>Sanddollar (keyhole urchin)</th>
<th>Sea Whip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polychaete Worms</td>
<td>Sea Urchin</td>
<td>Sea Pansy</td>
</tr>
<tr>
<td>Plumed</td>
<td>Penetrate</td>
<td></td>
</tr>
<tr>
<td>Parchment Worm</td>
<td>Sea Lettuce</td>
<td>Sea Pork</td>
</tr>
<tr>
<td>(also a polychaete)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cannonball Jellyfish</td>
<td>Driftwood</td>
<td>Barnacles</td>
</tr>
</tbody>
</table>

"Miscellaneous"
HOW LEVEL IS NANNY GOAT BEACH?

PURPOSE: To investigate the elevation (slope) of Nanny Goat Beach.

MATERIALS: 2 meter sticks
            string or line level (available at any hardware store)
            super glue

PROCEDURE:
Before going to the beach, super glue the string level to the flat side of one of the meter sticks.
The meter stick without the level will be referred to as meter stick #1. The meter stick with the level will be meter stick #2.

1. Standing at the water's edge, place the meter stick #1 upright with the zero mark on the sand.
2. Place meter stick #2 on the sand at the base of stick #1. Raise the end closest to the water until the bubble in the level is centered.

3. Record this elevation in centimeters in the data table.
4. Move stick #1 to the end of stick #2 (toward the dunes) and repeat step #2. Record this elevation in the data table.

5. Continue moving up the beach in this manner, recording the elevation every meter until you reach the base of the dunes.
6. Prepare a graph of the data you collected. This will give you a cross-section of the beach.
7. Answer the questions:
ANSWER THE FOLLOWING QUESTIONS:

1. What is the difference in elevation from the edge of the ocean to the base of the dunes?

2. What is the rise in elevation in centimeters per meter from the ocean to the base of the dunes?

3. Are there any locations where the elevation sharply increases or decreases? If so describe them.

4. Do you think that the elevation of the portion of the beach that you measured will always be the same? Explain your answer.

5. Islands to the north and south of Sapelo and Georgia have a greater wave energy. Would the elevation of those beaches be steeper or less steep that Sapelo? Explain your answer.

6. How would the elevation of beaches with wave energies less than that of Sapelo compare to the elevation of Sapelo's beaches?

CONCLUSION: Using what you have learned about waves, tides, currents and seasonal changes of the beach, explain what is responsible for the elevation of Nanny Goat beach.

EXTENSIONS: Repeat this activity at different locations along the beach and compare the elevations. Is the elevation of the beach the same or different at different locations? Explain.
<table>
<thead>
<tr>
<th>CONTINUED</th>
<th>ELEVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTINUED</td>
<td>DISTANCE</td>
</tr>
<tr>
<td>DATA TABLE CONTINUED:</td>
<td></td>
</tr>
<tr>
<td>CONTINUED</td>
<td>ELEVATION</td>
</tr>
<tr>
<td>CONTINUED</td>
<td>DISTANCE</td>
</tr>
<tr>
<td>DATA TABLE CONTINUED:</td>
<td></td>
</tr>
<tr>
<td>CONTINUED</td>
<td>ELEVATION</td>
</tr>
<tr>
<td>CONTINUED</td>
<td>DISTANCE</td>
</tr>
<tr>
<td>DATA TABLE CONTINUED:</td>
<td></td>
</tr>
<tr>
<td>CONTINUED</td>
<td>ELEVATION</td>
</tr>
<tr>
<td>CONTINUED</td>
<td>DISTANCE</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>CENTIMETERS</th>
<th>ELEVATION IN</th>
</tr>
</thead>
<tbody>
<tr>
<td>OF WATER IN METERS</td>
<td>DISTANCE FROM EDGE</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
COASTAL BIRD OBSERVATIONS

During your trip to Sapelo, record the following information for each bird that you observe.

<table>
<thead>
<tr>
<th>Bird Name</th>
<th>Where observed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What was it doing when you observed it?  

Explain how it is adapted for its habitat:  

Other Observations:

<table>
<thead>
<tr>
<th>Size (approx. in inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Beak (size, shape and color)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Legs (length and color)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feet (shape, size and color)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Feeding habits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

G-46
<table>
<thead>
<tr>
<th>Boat-tailed Grackle</th>
<th>Ring Billed Gull</th>
<th>Solitary Sandpiper</th>
<th>Little Blue Heron</th>
<th>Brown Pelican</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Crow</td>
<td>Herring Gull</td>
<td>Least Sandpiper</td>
<td>Black-crowned Night-Heron</td>
<td>Double-Crested Cormorant</td>
</tr>
<tr>
<td>Northern Mockingbird</td>
<td>Royal Tern</td>
<td>Sanderling</td>
<td>Turkey Vulture</td>
<td>Great Blue Heron</td>
</tr>
<tr>
<td>Mourning Dove</td>
<td>Least Tern</td>
<td>White</td>
<td>Opry</td>
<td>Great Egret</td>
</tr>
<tr>
<td>Pileated Woodpecker</td>
<td>Black Skimmer</td>
<td>Laughing Gull</td>
<td>Clapper Rail</td>
<td>P. Snowy Egret</td>
</tr>
</tbody>
</table>
Beach Clean-up - Teacher Instructions

1. Before planning your beach clean-up, call or write to the Sapelo Island National Estuarine Research Reserve (SINERR) to request permission and assistance in removal of the trash you collect. Contact: Fred Hay or Buddy Sullivan, Georgia Department of Natural Resources, SINERR, Post Office Box 15, Sapelo Island, Ga. 31327. Phone Number: 912-485-2251.

Be sure to check the tide schedule. It is best to begin the beach clean-up as the tide is going out. This will ensure enough time to walk the entire beach and return before the tide is high again.

2. Discuss safety precautions with the students:
   1. Do not go near large drums.
   2. Be careful of sharp objects (glass and syringes)
   3. Wear gloves
   4. Stay out of the dunes

3. Divide the students into groups of three. One student will act as the recorder and mark all trash items collected on the tally sheet. Another student will collect the trash. The third student should hold the bag. They may want to switch roles every 30 minutes or so.

   Each group of students will need several trash bags, a pen or pencil, tally sheet, and something to bear down on (clip board).

   At the beach send half the class northward, up the beach and the other half southward, down the beach. Remind the students of how much time they have to collect. Tell them when to turn around and return to the starting location, collecting full garbage bags along the way.

   When the trash bags become full or too heavy, the students should leave them above the high tide line. As they return to the starting location, they should pick them up again. All bags should be returned to the starting location, not left on the beach.

4. Instruct students on how to tally their trash. Place a slash mark beside each type of trash collected (one slash mark for each piece of trash). When you have collected all your trash, total each category and place this number at the end of each item line.

   When all trash is collected, total the tally sheets from each group.

5. Send the totals of all the trash collected to: Center For Marine Conservation
   (send a copy of your tally sheet with all totals on it)
   International marine Debris Database
   306 A Buckroe Ave.
   Hampton, VA 23664

The Center for Marine Conservation has collected and analyzed marine debris data since 1986. Their statistics are used in reports, public testimony and at international meetings to determine how plastic trash will be handled by ships at sea, at ports and on land all around the world.
# Beach Debris - Tally Sheet

Make a slash mark on the line beside the name of the item collected. Place the total number of items collected at the end of the line. Example: Egg Cartons /\/

## PLASTIC:
- bags:
  - Trash
  - Other
- bottles:
  - beverage, soda
  - bleach, cleaner
  - oil, lube
  - other
- buckets
- caps, lids
- cups, spoons, forks, straws
- diapers
- disposable lighters
- fishing line
- fishing net (> 2 ft.)
- fishing net (< 2 ft.)
- floats & lures
- hardhats
- light sticks
- milk, water jugs
- pieces
- rope:
  - longer than 2 feet
  - 2 feet or shorter
- 6-pack holders
- strapping bands
- syringes
- sheeting:
  - longer than 2 feet
  - shorter than 2 feet
- tampon applicators
- toys
- vegetable sacks
- other (specify)

## STYROFOAM (or other plastic foam):
- buoys
- cups
- egg cartons
- fast-food containers
- meat trays
- pieces:
  - larger than a baseball
  - smaller than a baseball
  - other (specify)

## RUBBER:
- balloons
- gloves
- tires
- other (specify)

## METAL:
- bottle caps
- cans:
  - aerosol
  - beverage
  - food
  - other
- crab/fish traps
- 55 gallon drums:
  - rusty
  - new
  - pieces
  - pull tabs
  - wire
  - other

## PAPER:
- bags
- cardboard
- cartons
- cups
- newspaper
- pieces
- other (specify)

## WOOD:
- (leave all wood on beach)
- crab/lobster traps
- crates
- pallets
- pieces
- other (specify)

## CLOTH:
- clothing/pieces
HOW TO!

SECTION-H
HOW TO TEST PERMEABILITY AND POROSITY

MATERIALS: tin can with both ends removed
            cup or tin can with only one end removed
            watch with a second hand
            ruler
            piece of wood
            water

PROCEDURE:

1. At each habitat on Sapelo, use the piece of wood to press the can that is open on both ends
   into the soil about one inch.
2. Lean the ruler against the inside of the can.
3. Fill the can with only one end removed full of water and pour this into the can you pressed into
   the soil. At each habitat be sure to fill the can to the same height. (Use the ruler to measure.)
4. Record how long it took for the soil to absorb all the water on your Sapelo Island Field Trip
   Data Sheet.
5. Back in the classroom, compare the time it took the same amount of water to be absorbed in
   each of the habitats. Discuss the permeability and porosity of the soil in each of the habitats.

HOW TO TEST TURBIDITY

Turbidity is a measure of the dissolved particles in water. It tells you how clear the water is or
how far light penetrates into the water. The amount of dissolved particles in the water determines
how deep sunlight will reach and therefore affects the photosynthesis (food production) that is
conducted by phytoplankton and other plants in the water. Sapelo's waters are naturally
somewhat turbid because of the detritus, other nutrients and plankton it contains. When run-off
from the mainland adds mud, sand, silt and pollution to the water the food production capacity of
the plankton is adversely affected.

Scientists use a Secchi Disc to test turbidity (may be purchased from a scientific supply company
or you may make your own). The Secchi disc is lowered into the water by a rope that is marked
off in meters until it disappears. This depth is the depth to which light can penetrate.

To measure turbidity, use the turbidity index: 100 divided by the number of feet lowered before
the Secchi disc disappears. If the disc dissappears at 25 feet, the turbidity index is 4; if the disc
disappears at 2 feet, the index is 50. There is a direct relationship between turbidity and pollution.
50 is more polluted or turbid than 2!
TO MAKE YOUR OWN SECCHI DISC

MATERIALS:

- Thin plywood or metal cut into circle 10 inches in diameter.
- Large eyebolt
- Two nuts and two washers
- Black and white enamel paint and paintbrush
- Drill
- 50 feet of strong chord or rope
- Ruler or measuring tape

Procedure:
1. Cut the plywood or metal into a circle 10 inches in diameter.
2. Drill a hole large enough for the eyebolt to fit through.
3. Paint the circle black and white (like the pieces of a pie - one white, one black, etc.).
4. Push the eyebolt through the hole and keep it in place with a washer and nut on either side of the wood.
5. Tie the chord or rope to the eyebolt.
6. Mark the chord with a permanent marker every meter (or tie knots every meter).

HOW TO TEST DISSOLVED OXYGEN

The amount of oxygen that is dissolved in the water is a very important indicator of the water. There are several ways that oxygen can get into the water: diffusion at the surface; aeration by breaking waves and by photosynthesis occurring in aquatic plants. Three-fourths of all the world’s oxygen supply is produced by oceanic algae.

Temperature controls the amount of oxygen that water can hold. Warm water holds less oxygen than cold water if everything else is the same. In addition to temperature, the amount of oxygen present is determined by the number of organisms using the oxygen, weather conditions, the time...
of day, the season of the year and the amount of decomposition or chemical activity occurring in
the water.

The amount of oxygen an organism requires depends upon its species, the temperature of the
water and the physical state of the organism. Because of these variables it is difficult to predict an
organism's specific oxygen demand. Most populations of fish require at least 4 - 5 ppm (parts per
million) dissolved oxygen to live and up to 9 ppm to reproduce. When the dissolved oxygen
content drops below 3 ppm, most fish die.

To test for dissolved oxygen, one needs a dissolved oxygen test kit. These are available from any
science supply company. The directions on how to use the kit are different for each kit.

HOW TO CONSTRUCT YOUR OWN PLANKTON NET

MATERIALS:

1 pair pantyhose
baby food jar (save lid)
metal or plastic ring, 1 inch in diameter
6 inch, nylon cable tie
5 inch or 6 inch plastic embroidery clamp
36 inches of twine or heavy duty chord
scissors
electric hand drill with 3/16 inch drill bit

PROCEDURE:

1. Drill 3 holes through the embroidery ring, 120° apart.

2. Cut the twine or chord into three equal lengths (12 inches each).

3. Thread each piece of twine through one of the holes in the outer part of the embroidery
   ring.

4. Attach the other end of all three pieces of twine to the one inch metal or plastic ring
   (this is your tow ring).

5. Cut one leg of the panty hose near the top of the leg and about 1/2 way to the knee.

6. Clamp the widest part of the pantyhose in the embroidery ring.

7. Attach the other end of the panty hose to the baby food jar with the cable tie.

8. Attach the rope to the tow ring.

NOTE: If your plankton net is too bouyant and will not sink below the surface, attach a fishing
weight.
INTERDISCIPLINARY ACTIVITIES

SOCIAL STUDIES:

1. Use the information in the History section to make a time line.
2. Prepare migration reports and a migration map of the birds seen on Sapelo.
3. Research the "Gullah" history.
4. Research some of the previous owners of Sapelo and their contributions to the history of Georgia.
5. Study historical uses of salt marshes by the Indians and the colonists.
6. Study the history of the fishing and/or shrimping industry in Georgia.
7. Invite one of the local residents of Sapelo to speak to your class about life on the island.
8. Research the early inhabitants of Sapelo and Georgia's other barrier islands. Make a video using drawings or creative dramatics.
9. Research what life would have been like on Sapelo during any particular period of its history. (research dress, family life, transportation, food, etc.)
10. Conduct an interview with the oldest members of the Hog Hammock Community. Find out what life was like during their youth. Interview a young Hog Hammock resident. What is their life like today?
11. Investigate the history of shipbuilding and Georgia’s contribution.
12. Investigate the import/export industry of Georgia’s coastal regions.
13. Investigate the kinds of boats.
14. Learn to read navigational charts and maps.
15. Students who have relatives that live on Sapelo could prepare a family tree.

LANGUAGE ARTS:

1. Write a "Biography of a Beach" (Island, Marsh, Maritime Forest, etc). Describe events that may have happened from the beach's (island, marsh, maritime forest, etc) point of view. The biography can be factual or imaginative.
2. Write "Island Poems."
3. Sit quietly for about 5 minutes listening to the sounds of the "Maritime Forest" (or any other habitat). What sounds do you hear? Write a poem or a story entitled "The Sounds of Sapelo's Forest."
4. Mystery Bird Descriptions: Have students write a description of a bird they saw on Sapelo. Exchange papers and using field guides or pictures from this manual, have other students try to identify the "Mystery Bird."
5. Have students write legends, fables, or songs about their experiences on Sapelo.
6. Have the students write a story about an ocean creature, marsh or ocean food web, history of Sapelo, etc. Then have them change their story into a play. The students could perform the play or create a stage and puppets to present their play.

7. Creative writing: Finish the sentence by writing a short story.
   "If I were a crab and tide went out, I would ............................................."
   "If I were a fiddler crab and the tide came in, I would ............................."
   "If I were a barnacle attached to a horseshoe crab, I would ...................."

8. Write a story about the travels of a sand grain.
9. Use the history of the island to write a historical fiction story that would take place on Sapelo.

**ART:**

1. "Shapes of Sapelo." Find as many different shapes as possible and make a collage of island shapes.
2. Paint a picture using different items found on the island. Use pigments from plants, leaves, stems, sand, etc.
3. Make clay models of favorite animal seen on Sapelo. (Dolphin, heron, egret, crabs, various shells, etc.)
4. Shell casts: in damp sand, press in your favorite shell. Pull it up and fill the depression with plaster of Paris; let dry.
5. Leaf prints: Collect leaves from the maritime forest floor to take back to the classroom. Place leaf on newspaper. Using a sponge or brush, add paint to the leaf. Put leaf with paint side down onto cloth, construction paper, etc., cover with newspaper and press or use a rolling pin. Be creative: the students can make wall hangings, note paper, placemats, etc.
6. Leaf rubbings: place leaf under paper. Using crayon or pencil, rub over the leaf.
7. Splatter prints: Use leaves, shells, sand dollars, seaweed, etc., thinned paint, old toothbrush, small piece of wire screening or thin stick. Arrange object to be painted on the paper. Dip toothbrush into the paint and let any drips fall back into the paint container. Hold toothbrush several inches above the paper and rub the bristles against the screening or stick, spattering paint onto the paper around your object.
8. "Sapelo Island Mural": Divide the class into groups. Each group draws a different habitat on a strip of butcher paper. Tape all habitats together.
9. Driftwood or shell mobiles.
10. "Sapelo Diorama": Have students build a diorama of Sapelo inside a shoe box.
11. Make "Sand Clay": Mix one cup sand and one-half cup corn starch, pour in boiling water and mix well. Cook briefly until mixture thickens. Wait a minute or so for the mixture to cool. Use imagination and model into your favorite island shape. Place on a flat cooking sheet and bake at 275° until dry (can dry without oven).
12. Create a Sapelo bulletin board. (You may want to choose a particular habitat or the entire island.)
13. Make "Camouflage Tubes." Have students choose an animal from the marsh, maritime forest, dunes, or beach and decorate a toilet paper tube with twigs, grasses, sand etc. to depict the camouflage adaptations of that animal for survival in its habitat.

14. Make shell sand candles: Press a shell into a container of lightly dampened sand. Pull the shell out so that it leaves an impression. Melt old candles or paraffin and pour into the shell depression. Quickly place a length of wick into the wax before it hardens. When the wax is dry, pull your candle out of the sand.

15. Sapelo is an excellent location for photography. Take pictures of lines, trunks of trees, patterns of palmetto, etc.

16. Gyotaku: *Japanese Fish Printing.* You could substitute treasures found on the beach. The print could be designed to tell a story or reflect the different seasons of the beach. To make a print, cover the work area with newspaper. Wash and dry the fish or whatever object is to be printed. Place the fish or other object on a piece of cardboard; brush a thin coat of paint or ink onto the object; lay a piece of newsprint, white paper, muslin, t-shirt, sheet (what ever you want) on top of the painted surface and press lightly. Carefully remove your print from the painted surface.

17. Make colored sand by adding colored powdered tempera in an empty container. Add sand purchased from a hardware store and shake. You can make several different colors, then have students draw designs or "Sapelo" scenes on a piece of heavy cardboard or poster board. Fill in each section with a thin coat of elmers glue (one color at the time). Sprinkle the colored sand over the glue and let dry. When one color is dry, proceed to the next color, etc.

18. Make kites or wind socks: Use fish, clams, dolphins, waves, Live Oak tree, etc. as the main theme for the kite or wind sock.

19. Take slides and sound recordings of the various areas visited and prepare a multi-media presentation of the day using slides, sound tapes and specimen collections.

**MATH:**

1. Visit the various "Tabby Ruins." Calculate the area of the buildings. If history can tell us the average number of people that inhabited the buildings, calculate the space in square feet per person.

2. Make graphs of the information collected in various activities: compare salinity of the water at Meridian Dock, Marsh Landing Dock, Long Tabby, Dean Creek along the nature trail, the ocean, the duck pond, etc. Make air temperature comparisons at the places mentioned above and/or at various locations along the nature trail.

3. Find the surface area of various shells collected from the beach. Find the average size for each, mean, median, mode, etc. Graph results and compare the different shells.

4. Prepare graphs of the plant and/or animal life found in each of the various habitats. Find the percentages of each animal/plant found.
SCIENCE:

1. Go on a "Bird Behavior Hunt." Observe the behavior and movement of the birds of Sapelo. Record your observations and discuss why they behaved or moved as they did.

2. Measure the velocity of the salt marsh creek. Measure about 5 yards downstream along the creek (mark the beginning and ending of the measurement). Drop a piece of wood or grass into the creek at the beginning. Time how long it takes for the wood or grass to float the 5 yards. Divide this time by 5 or whatever distance you measured. This is the speed the creek was flowing. It would be interesting to compare the speed of the creek during incoming and outgoing tides.

3. Make an underwater viewing can. Cut both ends out of a coffee can. Attach a strip of clear plastic or plastic wrap over one end with a large rubber band.

4. Using paper and tape only, have students create a creature that can withstand the crashing power of a wave. Make a wave using 5 pounds of bird seed in a pillow case. Drop the wave onto each creature to see if they survive.

5. Discover how sand dunes are made. On a day when the wind is blowing, place a pile of wrack or shells, or even an old shoe, on the dry sand. Watch what happens over a period of several minutes (you may want to do something else and come back in 30 minutes or so). Observe what has happened. Discuss this happened, and the importance of plants and other objects that slow the speed of the wind.

6. Establish the "ESTUARY TRAVEL AGENCY." Students should prepare travel itineraries for migratory residents of the estuary. These itineraries may be written as travel tickets, and then plotted on world maps.

7. Play "Estuary Quest" or "Marsh Quest" or "Beach Quest," etc. Divide the class into teams. Each team is competing against the other teams. Pin or tape the name of an estuary (marsh or beach) resident (use fact sheets for this information) on the back of each student. Each member of each team gets one turn to ask teammates 4 questions. These questions can only be answered by yes or no. If the student guesses his identity on the first question he/she earns 4 points for his team, 3 points if guessed on second question, 2 points if guessed on third question and 1 point if guessed on fourth question. After each team member has had a turn, tally the total points earned by each team. The winning team is the team with the most points.

8. Have each student create a food chain for each Sapelo Island habitat. Then take these food chains and create food webs. Be sure to discuss how loss of one member of a food chain in one habitat can affect the food chains and webs in other habitats.

9. Demonstrate the concept of the energy transfer in a wave rather than water movement by using the idea of a "stadium wave." Have students sit or stand in a straight line. Begin at one side and have the first student raise his hands above his head and then lower them. As soon as one student has his hands raised, the next student raises his and so on. Tell the students that if everyone participating in the "stadium wave" moved, they would all pile up at one end of the stadium. (The concept of energy transfer in a wave is much the same as the "stadium wave."

10. Beach scavenger hunt. Before visiting Sapelo, prepare a list of items that the students should look for on the beach. Be as creative as possible; some items might include: a bird track, bird feather, Styrofoam, an old shoe, a bone, plastic, algae, snail shell, milk carton, aluminum can,
tin can, fishing line, rope, etc. Divide the class into teams of 4-6 students, give each team a section of the beach in which they can search and a time limit. All teams must bring their items to teacher for verification. (Be sure to save any trash and remove it from the beach) The team with the most items wins.

11. Use sand to time sedimentation rates using a capped long plastic tube (make pie or bar graphs of the results). Compare sand from different parts of the beach taken at different times or seasons of the year.

12. Microbial study: collect samples of mud or sand from the salt marsh, a freshwater area, and the intertidal beach. Prepare a culture of each for bacteria. Make slides and examine the bacteria. Compare the different bacteria found in each environment.

13. Prior to making a trip to Sapelo, give each student a copy of a map of the island and have them predict where they think a dock should be or where would be a good location for a fort, or houses. Where would be the best location for the UGa. Marine Institute, the Big House, etc.? They can then compare their predictions with where development actually occurs.

14. Have students create a food web or an energy pyramid for the various habitats of a barrier island. Discuss how, even though they are separate habitats, they all are interdependent on each other. Many of the same organisms are members of the food web or pyramid of one or more habitats.

15. Make an adaptation card game: Draw pictures of various island organisms (both plant and animal) on one side of an index card. Use the pictures and make a list of as many adaptations of each organism as possible. Write the adaptations on separate cards. Use the cards to play a game of concentration. Place all the cards face down on the table in a big square. Turn over two cards; if the picture matches the adaptations, you may keep the pair and turn over two more cards. A turn ends when the two cards do not match up. The number of players will depend on the number of cards available for the game.
SOURCES OF MARINE RELATED INFORMATION

DIRECTIONS: When writing to the following addresses: ask for a teacher's packet, to be put on their mailing list, and a list of free or inexpensive educational materials they have available. Also ask for information on any particular topic that you are interested in. Those that have information listed are things that I found very good.

Atlantic Coast Conservation Association, P.O. Box 15034, Savannah, Ga., 31416, (913) 355-7323. Attention: Paul Glenn.
College of Marine Studies, University of Delaware 19958-1298. Ask for MAS Bulletin Series and MAS Note Series. (Have excellent publications on a variety of marine related topics.)
College of William and Mary, School of Marine Science, Virginia Institute of Marine Science, P.O. Box 1346, Gloucester Point, VA 23062-1346. (Excellent Marine Science Methods For The Classroom Series. It includes 12 facts sheets on observing, inferring, classifying, investigating, hypothesizing, identifying variables, measuring, etc.)
Cooperative Extension Service, U.S. Department of Agriculture, Virginia State University, Petersburg, VA. 23806. (Ask for 4-H Marine Project Units 1-4 and leaders guide, A Planning Guide For Field Study Programs/A Guide for Aquatic Field Study Programs. There is a small charge but they are worth it.)
Department of Environmental Protection, Florida Marine Research Institute, 100 Eighth Ave., S.E., St. Petersburg, FL 33701-5095. Ask for information on marine related topics. They have excellent pamphlets on salt marshes, coral reefs, mangroves, sea grasses, estuaries, turtles, manatee, and endangered species. Also ask for a publications list.
EPA Coastal Programs Division, 345 Courtland St. NE, Atlanta, Ga. 30365. (404) 347-1740. Ask for information on public outreach programs.
Florida Sea Grant College, P.O. Box 110409, University of Florida, Gainsville, FL 32611-0409. Florida Marine Education Resources Bibliography - $3.00. Florida's Estuaries - $2.00. Marine Education and Research Organizations in FL.- $8.00. Man Meets Coast - free.
Florida Keys-Lower Region, 216 Ann Street, Key West, FL. 33040.
Florida Keys National Marine Sanctuary, P.O. Box 500368, Marathon, FL 33037.
Georgia Department of Natural Resources, Coastal Resources Division, One Conservation Way, Brunswick, Ga. 31523-8600. Request map of Georgia's barrier islands and a list of materials available to teachers.
Gray's Reef National Marine Sanctuary, 10 Ocean Science Circle, Savannah, Ga. 31411.
and S. Carolina Coastal Resources Centers and information on the topic you need
information.
Gulf Coast Research Laboratory, J.L. Scott Marine Ed. Center and Aquarium, P.O. Box 7000,
Ocean Springs, MS 39564-7000. Excellent teacher's packet. Ask for reprints of "The Water
Column," the gift shop gift catalog, and a copy of Marine Education: A Bibliography of
Educational Materials from the Nations Sea Grant Programs - $4.00, but well worth it.
Jekyll Island Authority, 375 Riverview Dr., Jekyll Island, Ga. 31527.
Key Largo National Marine Sanctuary, P.O. Box 1083, Key Largo, FL 33037.
Louisiana Nature and Science Center, Inc., P.O. Box 870610, New Orleans, LA 70187-0610.
"Welcome to the Wetlands: An Activity Book for Teachers" - $15.00.
Louisiana Sea Grant, Communications Office, Louisiana State University, Baton Rouge, LA
The Marine Mammal Center, Marine Headlands, Golden Gate National Recreation Area,
Sausalito, CA, 94965-2697.
Minnesota Extension Service, U. S. Department of Agriculture, University of Minnesota, St. Paul,
Minnesota 55108. "Lake Game for Youth;" an excellent game involving decision making
skills - free.
Modern Curriculum, 4200 N Industrial Blvd., Indianapolis, IN 46254. Ask for information
Monterey Bay Aquarium, 886 Cannery Row, Monterey, CA 93940-1085. Ask for information on
a particular topic in addition to materials list.
National Aquarium in Baltimore, Education Department, Pier 3, 501 East Pratt St., Baltimore,
Maryland 21202-3194. Ask for "Ask the Aquarium Fact Sheets" series ($2.00), in addition
to the teacher's packet.
National Marine Fisheries Services, 9721 Executive Center Dr., N., St. Petersburg, FL 33702,
(813) 570-5325. Free posters on Sea Turtles, Fishes of the Gulf and S. Atlantic,
Crustaceans, Marine Mammals, and information on recreational fishing. For nine poster
series: call 1-800-228-5006 ($5.00 each)
National Marine Fisheries Service Hot-line: (813) 570-5554. Ask for information on a particular
topic.
New Jersey Department of Environmental Protection, Office of Communications and Public
Education, 401 East State Street, 7th Floor, Trenton, NJ 08625. Ask for educational
materials on marine topics --- EXCELLENT!
North Carolina Aquarium-Roanoke Island, P.O. Box 967, Airport Road, Manteo, NC 27954.
Director of Education, New England Aquarium, Central Wharf, Boston, Mass. 02110-3399. Ask
for materials list from teacher resource center. They will loan kits, filmstrips, videos, books,
etc. A GREAT RESOURCE!
NOAA'S Marine Debris Information Office, 1725 DeSales St, NW, Washington, DC 20036. In
addition to teacher's packet, ask for Marine Debris Educational Materials Directory.
NOAA National Marine Fisheries Service, 75 Virginia Beach Drive, Miami, FL 33149-1099.
Rookery Bay National Estuarine Research Reserve, 10 Shell Island Road, Naples, FL 33962.
Sea World of California, 1720 South Shores Road, San Diego, CA.
Sea World of Florida, 7007 Sea World Drive, Orlando, FL 3281-8097.
Sea World of Texas, Education Department, 10500 Sea World Drive, San Antonio, TX 78251-3002. In addition to teacher's packet, ask for Marine Mathematics for the Secondary Classroom. $8.00.

Texas A&M University at Galveston, P.O. Box 1675, Galveston, Texas 77553-1675. Marine Organisms in Science Teaching, 192 pages of activities ($4.00).

U. S. Department of Commerce/NOAA, PA/Correspondence Unit, 1305 E. West Highway, #8624, Silversprings, MD 20910. Ask for Coastal Awareness Guide and internet instructions.

University of Illinois at Urbana-Champaign, 124 Mumford Hall, 1301 West Gregory Dr., Urbana, IL 61801. Wetlands are Wonderland: Teacher guide, $3.50; youth guide, $3.00.

University of Georgia Marine Extension Service, 30 Ocean Science Circle, Savannah, Ga. 31411, (912) 598-2496.

University of Maryland, Sea Grant College Program, 0112 Skinner Hall, College Park, MD 20742. Marine Science Education Workbooks: Tides and Marshes UM-ES-79-01 ($2.00) and Food Webs in an Estuary UM-SG-ES-79-02 ($2.00)

University of Hawaii, Sea Grant Communications, 1000 Pope Rd., MSB 200, Honolulu, Hawaii, How to Use the Library to Find Marine-Related Information UNHI-Sea Grant-AB-84-02 (free).

University of North Carolina Sea Grant College Program, Box 8605, North Carolina State University, Raleigh, NC 27695-8605. Excellent Manuals: Unit One: Coastal Geology UNC-SG-78-14-A ($3.50); Unit Two: Sea Water UNC-SG-78-14-B ($2.00); Unit Three: Coastal Ecology UNC-SG-78-14-C ($2.00); Unit Four: Coastal Beginnings UNC-SG-78-14-D ($2.00).


U. S. Fish and Wildlife Services, 4270 Norwich St., Brunswick, Ga. 31520-2523, (912) 265-9336. Attention: Deborah Harris.

The Whale Museum, 62 First St. N, P.O. Box 945, Friday Harbor, WA 98250.

Woods Hole Information Office, Woods Hole Oceanographic Institution, Woods Hole, Mass., 02543. In addition to teacher's packet, ask for list of publications and Oceanography Reading Lists for Students/Adults. Also ask for: Field Guide Sheet for Eastern Shore Marine Environments. 11 x 17 sheets with poster on one side and written description on the other for the sandy shore and dunes, marshes, tidal flats, and salt ponds.
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