

# Coastal Processes:

## Erosion and Deposition of Georgia's Newest Barrier Island

### “Little Blackbeard”

Assembled and Modified by:

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#### **Overall Standards: Earth Systems--Science Georgia Standards of Excellence:**

- SES3. Obtain, evaluate, and communicate information to explore the actions of water, wind, ice, and gravity as they relate to landscape change.
  - d. Construct an argument based on evidence that relates the characteristics of the sedimentary materials to the energy by which they were transported and deposited.

#### **Overall Unit Objective:**

While participating in the GCE-LTER Schoolyard Program on Sapelo, one of the crowd favorites every year is to visit Cabretta Beach on our Barrier Island tour. From this unique viewpoint, participants can get a good look at Georgia's newest barrier island, Little Blackbeard, as well witnessing firsthand the erosional changes that are sure to come. This learning unit will investigate barrier island erosional features specific to the Georgia Coast, as well as how sudden changes can alter that erosion over time.

# Lesson 1: Who Moved the Beach?

([https://oceanservice.noaa.gov/education/lessons/who\\_moved\\_the\\_beach.html](https://oceanservice.noaa.gov/education/lessons/who_moved_the_beach.html))

## Shoreline Erosion / Grades 9-12 / Earth Science

### Focus Question

What are the primary causes and impacts of coastal erosion, and how should human communities respond to this process?

### Learning Objectives

1. Students will identify coastal erosion as a natural process, and explain how human activity can increase the risks associated with coastal erosion.
2. Students will identify options for reducing risks caused by coastal erosion, and discuss the advantages and problems associated with these options.
3. Students will analyze and interpret beach elevation data, and make inferences from these data about the relative vulnerability of different beaches to coastal erosion.

### Links to Overview Essays and Resources Useful for Student Research

<http://www.oceanservice.noaa.gov/topics/coasts/assessment/>  
<http://coastalmanagement.noaa.gov/hazards.html>

### Materials

1. (optional) Computers with Internet access; if students do not have access to the internet, download copies of materials cited under “Learning Procedure” and provide copies of these materials to each student or student group.
2. Copies of “Coastal Erosion Subject Review Worksheet” at the end of this lesson - one copy for each student or student group.
3. Graph paper or computers with spreadsheet and graphing software.

### Audio/Visual Materials

None.

### Teaching Time

One or two 45-minute class periods, plus time for student research

### Seating Arrangement

Classroom style, or groups of 3-4 students

### Maximum Number of Students

30

## **Key Words**

Erosion  
Accretion  
Longshore transport  
Dune  
Berm  
Beach profile

## **Background Information**

Almost half of the people living in the United States live near the coast. As the coastal population continues to grow, more people and property will be exposed to hazards caused by severe storms, floods, shoreline erosion and other natural hazards. Homes and businesses are often built in low-lying areas and barrier islands that are particularly vulnerable to storm damage. The potentially disastrous consequences of this trend became obvious during the summer of 2004 when residents of Florida were battered by four major hurricanes within six weeks, resulting in billions of dollars' worth of damage. Much of the price is eventually borne by American taxpayers through federal government funds for disaster relief and reconstruction.

While erosion and land subsidence (land sinking below sea level), are less spectacular than strong storms, they are just as important in economic terms. Erosion alone is estimated to cause billions of dollars of damage every year along U.S. coasts. Subsidence around New Orleans has necessitated large expenditures for pumping and dike maintenance. Subsidence in Texas, Florida, and California threatens high-value land uses and causes damages that cost millions to repair.

Attempts to protect against coastal hazards can cause additional problems. Sea walls intended to protect against storm waves can actually accelerate beach erosion and reduce the capacity of beaches to absorb storm energy. As a result, buildings adjacent to the beaches are exposed to the full force of wind and waves. Human activities such as diking and drainage of land around New Orleans, ground water removal in Texas and Florida, and extraction of oil and gas in California have accelerated subsidence in these areas (see, for example, <http://ga.water.usgs.gov/edu/earthgwlandsubside.html>).

Experience has shown that prevention is the best approach to deal with these problems. It costs much less to prevent construction in areas unsuitable for development than to provide funds for emergency response, cleanup, and reconstruction. NOAA's Office of Ocean and Coastal Resource Management works in partnership with state governments to minimize the impact of coastal hazards by

- Identifying areas that are most likely to be severely affected by these hazards;
- Developing warning systems and response plans to minimize human exposure to hazardous events;
- Establishing appropriate building codes; and
- Restoring the natural protective functions of beaches and dunes.

From 1996 to 2000, the National Ocean Service, NASA, and U.S. Geological Survey partnered in an Airborne LIDAR Assessment of Coastal Erosion (known as the ALACE project). LIDAR stands for light

detecting and ranging, and is part of NASA's Airborne Topographic Mapper (ATM). The ATM system uses a laser altimeter installed in an aircraft. As the aircraft flies along the coast, the altimeter scans the earth's surface in a path several hundred meters wide, and acquires an estimate of ground elevation every few square meters. The ALACE project collected topographic data (elevations of dunes and beaches) along U.S. coasts. These data have been used to create maps that show the relative vulnerability to coastal erosion. These maps can be used to quickly locate areas that may be severely impacted by coastal storms, to help plans for emergency response as well as environmentally appropriate development. For more information on LIDAR mapping, visit <http://www.csc.noaa.gov/products/nchaz/html/ldarmenu.htm>.

In this lesson, students will learn about the major causes and impacts of coastal erosion, and will use elevation data to construct profiles of three beaches and make inferences about erosion processes on these beaches.

### **Learning Procedure**

Note: If you want to introduce this lesson by showing images of severe coastal erosion, such as that caused by hurricanes, visit <http://www.photolib.noaa.gov/index.html/>; under the "Collections" tab, click on "Nat'l Weather Service, then click on the "Search" tab and enter "erosion."

1. Tell students that their assignment is to learn about coastal erosion processes by completing the "Coastal Erosion Subject Review Worksheet." If students do not have access to the internet, download copies of materials cited at the beginning of the worksheet and make one copy of each article available to each student or student group.
2. Review answers for the worksheet. The correct answers are:
  1. Beach sand originates mainly from rivers and streams, and also comes from weathering of exposed rock formations, and from the deterioration of shells, corals, and skeletal fragments.
  2. Coastal erosion is a natural process that removes sediment from shorelines. Another natural process that deposits sediment on shorelines is known as accretion.
  3. Sand is generally moved offshore by high-energy waves during winter months, and is returned by gentle waves during summer months.
  4. Movement of sand parallel to the coast by wave action, wind, and currents is known as longshore transport.
  5. Sea walls, jetties, and bulkheads may contribute to erosion because they affect natural water currents and prevent sand from shifting along coastlines to replenish beaches.
  6. The first dune ridge or beach berm (if there is no dune present) are the "first line of defense" against coastal erosion from wind and waves.
  7. Barrier islands are composed primarily of sand and are the most dynamic land masses along the open-ocean coast.

8. The impact of a storm on a barrier island is dependent on storm characteristics and the elevation of the barrier island when the storm makes landfall.
9. The Coastal Change Hazard Scale categorizes net erosion during storms into four impact levels or “regimes.”
10. In the Collision Regime, waves cross the base of dunes, causing erosion and semi-permanent changes.
11. In the Inundation Regime, storm waves are high enough to completely submerge the island, allowing sand to be transported over a distance of one or more kilometers toward the mainland.
12. In the Over-wash Regime, waves exceed the elevation of the dune or beach berm (if no dune is present), causing sand to be transported toward the mainland so the barrier island “migrates” landward.
13. In the Swash Regime, waves are confined to the beach. Sand may move offshore, but will be eventually returned so there is no net erosion.
14. Over the next 60 years, erosion may claim one of every four houses within 500 feet of the U.S. shoreline. (According to a study by H. John Heinz III Center for Science, Economics and the Environment; see “Resources”)
15. Most of the damage from erosion over the next 60 years will occur in low-lying areas that also have the highest risk from flooding.
16. When the Cape Hatteras lighthouse was constructed in 1870, it was 1,500 feet from the shore. By 1987, the lighthouse was 160 feet from the sea due to coastal erosion.
17. About 87,000 homes are located on low-lying land or bluffs that are likely to erode into the ocean or the Great Lakes over the next 60 years.
18. Without additional beach nourishment or structural protection, roughly 1,500 homes and the land on which they are built will be lost to erosion each year. (According to a study by H. John Heinz III Center for Science, Economics and the Environment; see “Resources.”)
19. The average annual erosion rate along the Atlantic coast is about 2 to 3 feet.
20. The highest erosion rates in the United States are in coastal areas bordering the Gulf of Mexico.
21. A major storm can erode the coast inland 100 feet or more in a single day.
22. The Atlantic coast has the largest number of structures located within the 60-year erosion hazard area.
23. Ecological concerns related to erosion arise primarily because of the scarcity of wetlands.

24. Coastal erosion may increase during the next 50 to 100 years if polar ice caps melt and cause a rise in sea levels.
25. People have three choices when erosion poses a threat: leave, renourish, or build.
3. Review the idea of the ALACE project and LIDAR mapping (which students may have encountered while researching answers for the worksheet). Ask students what sorts of beach profiles might be most resistant to wave erosion. Provide each student or student group with copies of the text file "threebeaches.txt" and instruct each group to plot each of the four sets of data on a single graph. If possible, have students import the data into a spreadsheet program (such as Microsoft Excel) and use this program to construct their graph. Detailed directions for this process are provided on the worksheet.
4. Lead a discussion of students' beach profiles. Ask students to infer which of the three beaches might be most vulnerable to wave erosion. Paradise Beach and Shell Beach both have conspicuous dunes, while Donkey Beach has a lower elevation and would be more susceptible to erosion by waves. Ask what might account for the differences in the two profiles for Paradise Beach. Students should recognize that in March the beach may have been recently exposed to winter storms that increase erosion and move sand offshore, but that by September this sand could have been returned by the gentler waves typical of summer months. Be sure students realize that the offshore areas that receive eroded sand are obviously involved in these processes, and in fact are part of the total beach profile.

Discuss the three options for responding to erosion threats listed in the last question on the worksheet. Students should realize that while leaving may be the least expensive option, this is often impractical where development has already taken place. Renourishment, however, is seldom a permanent solution (see <http://www3.csc.noaa.gov/beachnourishment/html/human/case.htm> for an example). Similarly, various construction options can make property more resistant to erosion, but structures such as sea walls, jetties, and bulkheads often increase erosion and shift the problem to other areas by interrupting the natural flow of sand.

### **The Bridge Connection**

The Bridge is a growing collection online marine education resources. It provides educators with a convenient source of useful information on global, national, and regional marine science topics. Educators and scientists review sites selected for the Bridge to insure that they are accurate and current.

<http://www.vims.edu/bridge/archive0500.html> – "Coastal Erosion: Where's the Beach?"

<http://www.vims.edu/bridge/> – In the navigation menu on the left, click on "Ocean Science Topics," then "Marine Geology" for links to resources on beaches and coastal erosion.

### **The "Me" Connection**

Many people who live in erosion-prone areas believe that they have the right to take whatever steps are necessary to protect their property from erosion. For example, a 1998 report in the Maryland Law Review points out that more and more houses are being built just inland of sandy beaches that are

generally considered to be public lands. Because sea level is rising and most shores are eroding, the ocean will eventually reach these houses unless the houses are moved or the sea is held back. The most common “solution” is to build a wall between the private dry land and the public beach. The result is that the private land is saved and the beach erodes away. In Maryland alone, more than three hundred miles of tidal shoreline have been “armored” in the last 20 years. For links to the full report, visit: <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsSLRTakings.html> (this report is a 2.2mb, 121 page pdf file).

Have students write an essay explaining why they support or reject this approach, and what arguments might be offered by someone with a view that opposes their own.

### **Extensions**

Visit [http://www.mostreamteam.org/Documents/how\\_to/streamtable.pdf](http://www.mostreamteam.org/Documents/how_to/streamtable.pdf) for information on building and using a stream table to simulate erosion and other processes involving sediment transport by water (presented by the Missouri Stream Team Info center).

### **Resources**

[http://www.csc.noaa.gov/crs/rs\\_apps/sensors/lidar.htm](http://www.csc.noaa.gov/crs/rs_apps/sensors/lidar.htm) – National Coastal LIDAR data from NOAA’s Coastal Services Center

<http://www.csc.noaa.gov/beachnourishment/> – Beach Nourishment: A Guide for Local Government Officials from the NOAA Coastal Services Center

<http://heinzhome.heinzctrinfo.net/publications/PDF/erosnsum.pdf#zoom=100> and <http://heinzhome.heinzctrinfo.net/publications/PDF/erosnrpt.pdf#pagemode=bookmarks&view=Fit> – summary report (23 pages, 544 kb) and full report (252 pages, 3.9 mb), “Evaluation of Erosion Hazards” prepared by the H. John Heinz III Center for Science, Economics and the Environment

<http://coastal.er.usgs.gov/hurricanes/> – U.S. Geological Survey “Hurricane and Extreme Storm Impact Studies” webpage

<http://archives.cnn.com/2000/fyi/news/09/20/coastal.erosion/index.html> – CNN fyi article, “Beaches on the brink”

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### **Who Moved The Beach?**

#### **Student Worksheet**

#### **Part I - Coastal Erosion Subject Review**

The following reports and articles contain the information needed to complete this worksheet:

“Evaluation of Erosion Hazards” prepared by the H. John Heinz III Center for Science, Economics and the Environment (summary Report)

<http://heinzhome.heinzctrinfo.net/publications/PDF/erosnsum.pdf#zoom=100>

“Coastal Change Hazards” U.S.G.S. Web site beginning at: <http://coastal.er.usgs.gov/hurricanes/cch.html>

“Coastal Erosion: Where’s the Beach?” Bridge Data Tip at: <http://www.vims.edu/bridge/archive0500.html>

“Beaches on the Brink” CNNfyi.com article at <http://archives.cnn.com/2000/fyi/news/09/20/coastal.erosion/index.html>

1. Beach sand originates mainly from \_\_\_\_\_, and also comes from \_\_\_\_\_, and from \_\_\_\_\_.
2. Coastal erosion is a natural process that removes sediment from shorelines. Another natural process that deposits sediment on shorelines is known as \_\_\_\_\_.
3. Sand is generally moved offshore by high-energy waves during \_\_\_\_\_ months, and is returned by gentle waves during \_\_\_\_\_ months.
4. Movement of sand parallel to the coast by wave action, wind, and currents is known as \_\_\_\_\_.
5. Sea walls, jetties, and bulkheads may contribute to erosion because \_\_\_\_\_.
6. The \_\_\_\_\_ or \_\_\_\_\_ (if there is no dune present) are the “first line of defense” against coastal erosion from wind and waves.
7. \_\_\_\_\_ are composed primarily of sand and are the most dynamic land masses along the open-ocean coast.
8. The impact of a storm on a barrier island is dependent on storm characteristics and the \_\_\_\_\_ of the barrier island when the storm makes landfall.
9. The Coastal Change Hazard Scale categorizes net erosion during storms into \_\_\_\_\_ impact levels or “regimes.”
10. In the \_\_\_\_\_ Regime, waves cross the base of dunes, causing erosion and semi-permanent changes.
11. In the \_\_\_\_\_ Regime, storm waves are high enough to completely submerge the island, allowing sand to be transported over a distance of one or more kilometers toward the mainland.
12. In the \_\_\_\_\_ Regime, waves exceed the elevation of the dune or beach berm (if no dune is present), causing sand to be transported toward the mainland so the barrier island “migrates” landward.
13. In the \_\_\_\_\_ Regime, waves are confined to the beach. Sand may move offshore, but will be eventually returned so there is no net erosion.
14. Over the next 60 years, erosion may claim \_\_\_\_\_ of every \_\_\_\_\_ houses within 500 feet of the U.S. shoreline.



15. Most of the damage from erosion over the next 60 years will occur in low-lying areas that also have the highest risk from \_\_\_\_\_.
16. When the Cape Hatteras lighthouse was constructed in 1870, it was \_\_\_\_\_ feet from the shore. By 1987, the lighthouse was \_\_\_\_\_ feet from the sea due to coastal erosion.
17. About 87,000 homes are located on low-lying land or bluffs that are likely to erode into the ocean or the Great Lakes over the next 60 years.
18. Without additional beach nourishment or structural protection, roughly \_\_\_\_\_ homes and the land on which they are built will be lost to erosion each year.
19. The average annual erosion rate along the Atlantic coast is about \_\_\_\_\_ feet.
20. The highest erosion rates in the United States are in coastal areas bordering \_\_\_\_\_.
21. A major storm can erode the coast inland \_\_\_\_\_ feet or more in a single day.
22. The \_\_\_\_\_ coast has the largest number of structures located within the 60-year erosion hazard area.
23. Ecological concerns related to erosion arise primarily because of the scarcity of \_\_\_\_\_.
24. Coastal erosion may increase during the next 50 to 100 years if polar ice caps melt and cause a rise in \_\_\_\_\_.
25. People have three choices when erosion poses a threat: \_\_\_\_\_, \_\_\_\_\_, or \_\_\_\_\_.

## **Part II – How to Graph Beach Profile Data Using Microsoft Excel®**

*Adapted from Bridge Beach Profile Graphing Exercise:* <http://www.vims.edu/bridge/beachgraph.html>

1. [Right click here](#), then select "Save As" to download the data as a tab delimited text file. If using a Mac, press the "control" button while clicking. Open the data file "who\_moved\_the\_beachdata.txt" in Excel®. You will get the Text Import Wizard.
  - Step 1 - Select Delimited, Start Import at Row: 1; be sure File Origin: matches the operating system you are using. Hit Next.
  - Step 2 - Select Delimiters: Tab and Text Qualifier: ". Hit Next.
  - Step 3 - Select Column Data Format: General. Hit Finish.
2. Select an empty cell, then click on the Chart Wizard icon.
  - Step 1 - Under Standard Types select Chart Type: XY (Scatter). Under Chart Sub-type select the first chart in the second row (scatter with data points connected by smooth lines). Hit Next.
  - Step 2 - Under the Data Range tab, click on the upward-pointing triangle (collapse dialog) icon to the right of the "Data range" box. Highlight cells A3 through H67. Click on the downward-pointing (open dialog) icon. Make sure the Series In: Columns is selected.

Under the Series tab, go to the box listing the different series which will correspond to Y-values on your graph. Series 1 corresponds to column B on the data sheet (Donkey Beach Elevations). Enter "Donkey Beach" in the "Name" box, then click on Series2. This series corresponds to column C (Paradise Beach Distance, March). Since we only want to plot elevations, click "Remove" to delete Series2 from the data. Continue this process, naming Series3, Series5, and Series7, and removing Series4 and Series6. Hit Next.

- Step 3 - Chart Options. Enter the titles, legend, etc. that you wish. The X axis is the horizontal distance and the Y axis is the beach elevation both have units of feet. It is recommended that the legend be placed at the bottom of the graph. Hit Next.
  - Step 4 - Select Place Chart As New Sheet: Chart 1. Hit Finish.
3. To print the graph, go to File then Print Preview to make sure the graph looks right on the page. To make adjustments go to Setup. When the graph is ready, select Print.
  4. To save the spreadsheet and graph, go to File, Save As and change the Save as type to Microsoft Excel Workbook.

## Lesson 2 and 3: Where's The Beach? – Investigating Ways to Protect Coastlines from Erosion

([https://natureworkseverywhere.org/\\_media/resources/whereisthebeach\\_V2.docx](https://natureworkseverywhere.org/_media/resources/whereisthebeach_V2.docx))

### Essential questions:

- How do waves cause coastline erosion?
- What engineering solutions protect coastlines?
- Which engineering solutions suit a particular type of coastline?
- How are oyster reefs beneficial to both people and the environment?

### Lesson Overview:

In this lesson plan, students look at different ways to protect coastlines. Students first use an online tool to find historic tide data in a selected coastal location: the Gulf Coast of the United States. Then students use a hands-on model to explore the use of different materials in protecting coastlines. As they progress, students learn how and why oyster reefs are being used to protect the coastline of the Gulf of Mexico. In this STEM lesson, students will get the opportunity to practice and learn across a wide range of disciplines.

### Learning Objectives:

#### *Evaluation*

- Model ways in which coastlines can be protected.

#### *Synthesis*

- Compare ways to protect coastlines.

#### *Analysis*

- Calculate wave energy from wave size.
- Investigate geographic data to analyze site characteristics related to ocean conditions.

#### *Application*

- Solve quantitative problems to illustrate differences between different coastal erosion protection solutions.

#### *Comprehension*

- Classify methods of coastal erosion protection as “hard” or “soft” engineering.
- Interpret tables and charts related to wave energy and size.
- Understand why coastal erosion is an important conservation issue with significant engineering challenges.

### *Knowledge*

- Know that engineering solutions to coastal erosion include use of natural systems as well as artificial structures.
- Know that coastal erosion has negative effects on human property and wildlife habitat.

### **Time Frame:**

This lesson will require four 45 minute sessions (each classroom activity will take two sessions).

### **Vocabulary:**

- *Oyster reef*: A shallow natural structure comprised of oysters, usually parallel to the shore line
- *Coastal erosion*: Result of wave action removing quantities of soil or sand or resulting in permanent incursion of salt water onto land

### **Nature Works Everywhere videos supporting this lesson plan:**

- introductory video ([The Amazing Oyster Reef](#))
- scientist interviews video – *see links below*
- waves impacting constructed barriers
- Meet the Scientist: [Jonathan Hoekstra](#)

### **Background for the Teacher:**

In this lesson plan, students study methods for protecting coastlines. Coastal erosion is a serious problem since almost half the U.S. population lives near or along the coast. Hurricanes and other strong storms cause a lot of damage to a beach in a short time. In this lesson students will learn that continuous waves are also a force that the ocean exerts over time, and can change a landscape just as much as a hurricane. Coastal erosion devalues or destroys property, impacts fisheries and necessitates expenditures for prevention and remediation. Engineers must first characterize a location in terms of risk. They need to know the wave history of a particular location. Students will use an online tool to select a specific location and then interpret charts to estimate maximum wave height. To evaluate the strength of different materials, students conduct a hands-on experiment using a wave table.

### ***Photos of coastal erosion (to use in lesson):***

- Before and After (U.S. Geological Survey)

Hurricane Katrina (Gulf coast, Louisiana)

[http://soundwaves.usgs.gov/2005/09/Katrina\\_chandel\\_pair1LG.jpg](http://soundwaves.usgs.gov/2005/09/Katrina_chandel_pair1LG.jpg)

Hurricane Rita (Gulf coast, Louisiana)

[http://coastal.er.usgs.gov/hurricanes/rita/photo-comparisons/loc2\\_holly\\_bch\\_la.jpg](http://coastal.er.usgs.gov/hurricanes/rita/photo-comparisons/loc2_holly_bch_la.jpg)

Hurricane Ike (Gulf Coast, Texas)

[http://soundwaves.usgs.gov/2008/10/Ike\\_XalBch\\_TX\\_Loc1LG.jpg](http://soundwaves.usgs.gov/2008/10/Ike_XalBch_TX_Loc1LG.jpg)

- Severe erosion

Hurricane Ike (Gulf Coast, Texas)

[http://www.srh.noaa.gov/images/bro/wxevents/2008/ike/photos/gulf\\_to\\_bay\\_access\\_4.JPG](http://www.srh.noaa.gov/images/bro/wxevents/2008/ike/photos/gulf_to_bay_access_4.JPG)

[http://www.srh.noaa.gov/images/bro/wxevents/2008/ike/photos/gulf\\_to\\_bay\\_access\\_4.JPG](http://www.srh.noaa.gov/images/bro/wxevents/2008/ike/photos/gulf_to_bay_access_4.JPG)

- Wave action (Texas)

<http://www.glo.texas.gov/what-we-do/caring-for-the-coast/images/coastal-erosion2.jpg>

- Land area change in Coastal Louisiana

<http://gallery.usgs.gov/videos/433>

***Coastal erosion facts and figures:\****

- The highest erosion rates in the U.S. are in coastal areas bordering the Gulf of Mexico.
- Over the next 60 years, erosion may claim one of every four houses within 500 feet of the U.S. shoreline.
- A major storm can erode the coast inland 100 feet or more in a single day.
- Coastal erosion may increase during the next 50 to 100 years if polar ice caps melt and cause a rise in sea levels.
- The Cape Hatteras lighthouse was constructed in 1870. At that time it was 1,500 feet from the shore. By 1987, the lighthouse was 160 feet from the sea due to coastal erosion.
- Coastal Louisiana wetlands make up the seventh largest delta on Earth, contain about 37 percent of the estuarine herbaceous marshes in the conterminous U.S., and support the largest commercial fishery in the lower 48 States. These wetlands are in peril because Louisiana currently undergoes about 90 percent of the total coastal wetland loss in the continental U.S.

\*Sources:

[http://oceanservice.noaa.gov/education/classroom/lessons/09\\_coastmanag\\_erosion.pdf](http://oceanservice.noaa.gov/education/classroom/lessons/09_coastmanag_erosion.pdf)

<http://gallery.usgs.gov/videos/433>

**Activities:**

**Session 1:**

Materials for teacher:

- Photos of coastal erosion
- Video of oyster reefs

Materials for each group of students:

- Computer with Internet access
- Wave Energy Calculation Worksheet (at the end of the lesson plan)
- Wave charts (Douglas Sea Scale)
- Calculator
- Graph paper

### Engage

1. Show before and after photos of coastal erosion as a result of hurricanes.
2. Explain that hurricanes cause extensive damage in a short time. Ask students what they believe causes the damage. Ask them to support their claims with evidence (personal observations of beaches, images of storm damage from news programs, etc.). Guide them to the conclusion that damage is caused by the energy in ocean waves. The impact can be devastating and gets the most media attention.
3. Since all waves have energy, ask students what they think might be the effect of smaller amounts of wave energy over time. Ask them to support their claims with evidence. (Students who have visited a beach may have noticed the shifting beach over time.) Note that students may believe that “natural” wave action does not affect beaches as much as large storms. Note their ideas and supporting evidence and come back to this during Explain in Session 2.
4. Divide students into pairs or small groups. Prep each group that they will be required to use the materials to make a list of the causes and consequences of coastal erosion.
5. In preparation for having them make a list of causes (Step 7), have each group review the coastal erosion facts and figures. Show the [coastal Louisiana USGS](#) video.
6. Review the Texas Land Office Causes of Erosion presentation <http://www.glo.texas.gov/what-we-do/caring-for-the-coast/coastal-erosion/causes-of-erosion.html>
7. Ask each group of students to make a list of the causes and consequences of coastal erosion. Lead them to specific examples, such as coastal erosion being caused by:
  - Occasional weather events such as hurricanes and storms
  - Extreme tide conditions
  - Regular waves over time
  - Human activity that alters natural barriers such as oyster reefs and salt or sea marshes.

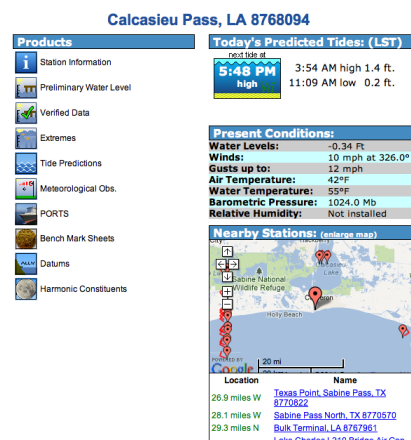
The effects of coastal erosion include:

- Devalues or destroys property
- Impacts fisheries by removing nursery habitats in shallow, low-lying areas

- Causes siltation of economically important waterways
  - Necessitates expenditures for prevention and remediation.
- Have groups create a concept map of coastal erosion. If needed, guide them to include why coastal erosion has serious consequences. Encourage groups to show in their concept map reasons why we want to control erosion, but at the same time keep coastlines beautiful and useful. For example, erosion destroys property but natural coastlines provide benefits for humans such as fisheries and recreation. Have students brainstorm to include in their concept map how people can control coastal erosion while minimizing environmental impact.
  - Present students the key question: How do scientists get the data to help them decide what structures and materials to use to protect coastlines?
  - Explain that they will use an online tool to find the kinds of wave data that scientists use.

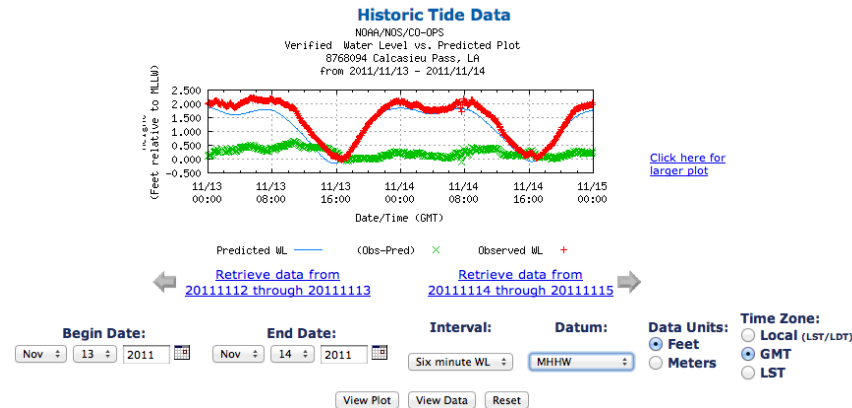
## Explore

- Demonstrate to students how to use the online tool (preferably with an interactive board).
- Use the NOAA website online tool: <http://tidesandcurrents.noaa.gov/>
- Click on the map of the United States.
- Click on one of the tabs (e.g., "Gulf Coast") or blue markers that represent regions. The map will zoom in so that students can access data from data collection stations.
- Click one of the red markers that represent data collection stations (Hint: hover over the marker to see the name of the station; e.g., Calcasieu Pass). A pop-up window provides preliminary information.
- Ensure the pop-up shows tide data. If tide predictions are unavailable for that location, select another location by clicking on a different red marker.
- Have students find sea level data for their selected location (Steps 11 to 14).
- Click "Station Home Page" in the pop-up window. A new window opens showing the station data:



9. Under the “Products” menu, click “Verified Data.”

10. Click Extremes. Click the radio button “Meters.” The page shows a graph of historic tide data.



11. The students’ goal is to find the highest recorded tide water level, as follows.

- 1) From the Interval drop down menu, select Monthly WL (water level).
- 2) From the Datum drop down menu, select MSL (Mean Sea Level).
- 3) Under Data Units select Meters.
- 4) In the Begin Date field for the year enter 2002 (10 years prior).
- 5) Click “View Plot”. The plot will refresh with the new data.
- 6) Click “View Data” A table will load with several columns. Under the column “Highest” find the largest number. (For example, for Calcasieu Pass, the data show that the highest recorded level above MSL was in September 2008, at 2.711 meters above mean sea level.)
- 7) If time allows, have students research online to investigate the cause of the high water. For example, Hurricane Gustav made landfall in Louisiana in September 2008. Explain to students that storm surge increases normal tide levels.

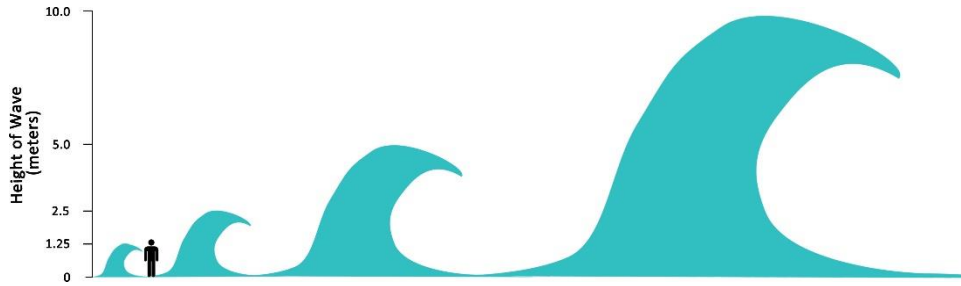
12. Introduce the concept of wave energy (Wave energy is measured in units of joules. In this activity we will be using a simple correlate in place of joules.)

13. Divide students into four groups. One group represents a wave 1.25 meters high, another group represents a wave twice as high (2.5 meters) and two more groups represent waves twice as high again (5 meters and 10 meters). Have the first group use a creative way to demonstrate a height of 1.25 meters, and have the other groups do the same for their respective heights.

14. Explain that their waves have energy. Have students brainstorm what they know about energy. Have them give examples of energy.



15. Have students try to assign values to the energy of their waves. The exact amounts or units are not important. Just keep students on track in terms of thinking about the energy in a wave.
16. Have students go back to their wave's representation of 1.25, 2, 5 or 10 meters. Ask students to compare the energy in each size of wave. For example, how much energy is in the 2 meter wave compared with the 1.25 meter wave?
17. Show students the wave graphic:



18. Divide students into small groups. Form differentiated groups so each group is formed of students of different math skills. Show students the following table (with two rows intentionally blank):

Wave height (m)	Wave energy
1	
2	4
3	
4	16

19. Have each group develop a hypothesis to explain how wave energy is related to wave height. Each group will then use their hypothesis to complete the table and explain their reasoning to the class. Again, the units of energy are not important, as long as each group has a relative quantity that relates the energy in one size wave to the energy in successively larger waves.
20. Ask students if they stick with their earlier conclusion about the amount of energy in each wave? (In most cases, students will first assume a wave that is twice as high as twice the energy). But the graphic makes them realize that the volume of the wave rather than just the height determines the energy. Because of the cube relationship between linear dimension and volume, the energy of the wave increases exponentially. You don't need to explain this to students. Just ensure they understand that the energy of the second wave is much more than twice that of the first.
21. Explain that wave energy depends on the overall size of the wave including its length and height. The wave energy that hits a coast depends on the size of the wave and other factors such as depth. Have the groups demonstrate how the wave energy of different sized waves causes

erosion. For example, the groups can use a T chart to show how many small waves over time might have comparable effects as one big wave.

22. Have students quantify the energy for their waves. For this activity students will use only the height of the wave.
23. Have students calculate the energy of a variety of waves, using information on the height of waves in the wave calculation worksheet (provided below).
24. Emphasize that these calculations are simplified, and that engineers use additional data when calculating wave energy in real-world applications.
25. Have students draw a graph of the data from the wave energy worksheet. The graph shows that wave energy increases exponentially as the size of the wave increases. (For independent inquiry have students determine the appropriate axes.)
26. Have students brainstorm to imagine examples of the effect of increasing power of waves with height. For example, if a barrier stops waves 1 meter high, does it have to be twice as strong to stop a wave 2 meters high?
27. Have each group of students propose the best solution to stopping their waves (1.25, 2, 5 and 10 meters). Remind students that biggest isn't always best because the appearance of a barrier and its construction cost are important, as well as its strength. (This serves as a useful prequel to the next lab.)

### **Explain**

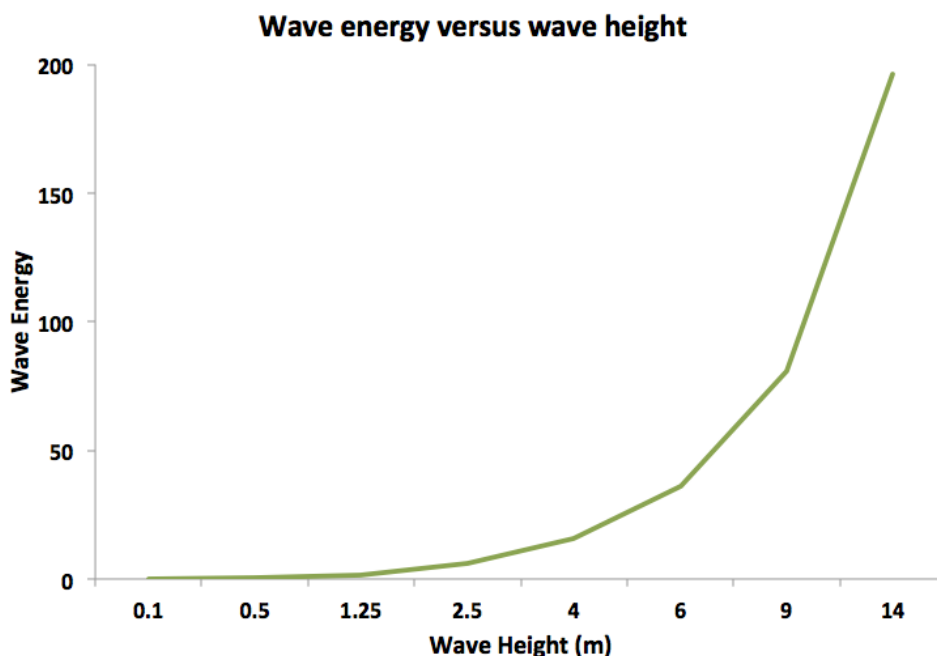
1. Have students create a graphic or poster to illustrate the various tide water levels.
2. Students should be able to describe the difference between different water levels that characterize measurement of historic tide data.
3. Have students characterize the causes and features of waves compared with tides. Have students draw a simple diagram to explain that waves occur as a result of wind, while tides are caused by the gravitational pull of the sun and moon, but both affect water level at any given time. (If students become confused on the difference, they can refresh their knowledge from the How Stuff Works page: <http://geography.howstuffworks.com/oceans-and-seas/the-geography-of-oceans7.htm>)
4. Ensure that students can explain the simplified procedure to calculate wave energy.
5. Have students devise a suitable metaphor for the relationship between wave height and energy. The basic concept for them to grasp is that energy increases non-linearly with height. That is, it is not a one-to-one relationship.
6. Have students create a simple graphic to show that erosion increases with wave energy. (This can be a graph showing a linear relationship between wave energy and erosion.)
7. Have the student groups write a brief report on why their solution to coastal erosion was better than other options.

## Extend

1. Have students research the general concept of energy in more detail. Wave energy, is measured in units of joules. Have students research this unit to characterize its definition and use. (They should learn that the joule is a measure of work done, which is the force exerted on something over a distance. If you move a toy car you exert a force over a distance. The work done, measured in joules, moves the car.)
2. Have students generate some examples to illustrate the joule. For example, it takes 0.005 joules to move a toy car weighing 10 grams at 1 meter per second. Or it would take about 100 joules to throw a football (about 410 grams) at 50 mph (22 meters per second), about the average speed of a throw for an NFL quarterback.
3. To help students prepare for the next lesson, have them brainstorm about how engineers use wave energy data to select different materials to protect a coastline.

## Evaluate

1. Have students self-evaluate how well they understood the tide and wave data, and can state that the wave strength is exponential to the wave height. Students should be able to take values for wave height and show that corresponding values for wave energy increase as a square of height.
2. Ensure that students can relate the amount of energy in waves to the amount of erosion caused by waves of different height.
3. Evaluate students on whether or not their calculations of wave energy were correct, and whether the graph was correctly drawn. Example graph:



Specific questions:

1. Use the descriptions of different sized waves to describe the waves during Hurricane Ivan that reached 7.6 meters.
2. Describe the relationship between energy and wave height that you observed in your graph.
3. In a low energy wave environment, would a high strong barrier be better than a low shallow one? Use evidence to support your answer.

#### **Scoring key for evaluation**

1. Waves of 7.6 meters are “High.”
2. Wave energy increases exponentially with wave height.
3. In a low energy environment a high strong barrier would likely be unnecessary. It would be more expensive than a low shallow barrier, and might be less attractive too. If the low barrier provides enough protection to do the job, it would be better than the high strong barrier.

#### **Resources and further reading**

<http://oceanworld.tamu.edu/resources/oceanography-book/coastalerosion.htm>

<http://onlinelibrary.wiley.com/doi/10.1111/j.1526-100X.2005.00062.x/full>

<http://el.erdc.usace.army.mil/elpubs/pdf/er01.pdf>

[http://www.eurometeo.com/english/read/doc\\_douglas](http://www.eurometeo.com/english/read/doc_douglas)

Huang, J., P. J. Poor and M. Q. Zhao. 2007. Economic Valuation of Beach Erosion Control. Marine Resource Economics 22: 221–238. <http://ageconsearch.umn.edu/bitstream/47052/2/01-Huang-05-91.pdf>

Panchang V. G. and D. Li. 2006. Large Waves in the Gulf of Mexico Caused by Hurricane Ivan. Bulletin of the American Meteorological Society 87: 481–489.

[http://spinner.cofc.edu/CGOInquiry/pdf\\_files/beacherosion.pdf](http://spinner.cofc.edu/CGOInquiry/pdf_files/beacherosion.pdf)

<http://www.1728.org/energy.htm>

[http://www.libraries.psu.edu/psul/lls/students/research\\_resources/conceptmap.html](http://www.libraries.psu.edu/psul/lls/students/research_resources/conceptmap.html)

#### **Session 2:**

##### **Background for the Teacher**

In this session students learn how different materials provide different levels of protection. For example, concrete and steel provide more protection than oyster reefs. However, artificial structures are more expensive to build. The Extend section of this session challenges students to develop a protocol for evaluating the cost-benefit of using different structures in locations with varying risk of wave damage. In situations where coastlines are subject to high energy waves, more robust (and expensive) barriers are

needed. Where coastlines are subject to low energy waves less robust (but cheaper) barriers will suffice. The kinds of barriers on the Gulf Coast are typically subject to lower energy waves, so natural barriers in the form of oyster reefs are a viable alternative to expensive artificial barriers.

Materials for teacher:

- Videos of oyster reefs
- Videos of scientist interview questions

Materials for each group of students:

- Concrete paver or paving brick (1" thick) (available from hardware stores)
- Marker pen
- Pebbles
- Ruler
- Sand
- Large shallow container or tub with long sides (or stream table)
- Timer (optional)
- Water
- Wooden board (same width as container)
- Gloves (optional)
- Waterproof apron

**Notes:** Use as lightweight a paver as possible, and ensure it is wide enough to reach as close as possible to the sides of the tub, without touching them. For example, if the tub is 12 inches high and 18 across, a suitable sized paver would be 10 inches long and 6 inches wide (preferably ½ inch thick). If you use a paver, the student handling it should wear gloves to avoid accidental abrasion. If a paver is unavailable, cut a plank to the appropriate dimensions. Use duct tape to secure heavy washers to the plank. The idea is to weight the plank so it will sink immediately after being dropped into the water. Students should be advised to wear a waterproof apron to avoid being wet by inadvertent splashes. Use as big a tub as possible for best results. A large baking pan may suffice, but it will be more difficult to make suitable waves.

## Engage

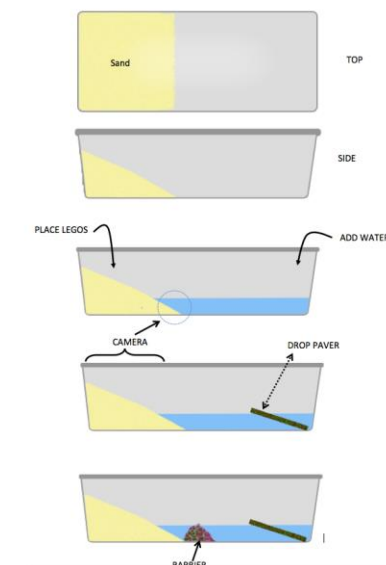
1. Show the [Amazing Oyster Reef](#) introductory video followed by the scientist interview video that answers the question, "[How does an oyster reef protect coastlines and therefore people?](#)"
2. Have students form pairs and discuss photos and video where sea defenses have failed. Encourage the pairs to list the possible solutions for sea defenses, based on the photos and videos.

3. Have each pair choose just one solution to protecting people and property along coastlines. Have each pair explain why they chose that particular solution, justifying their decision based on the photo and video evidence. If necessary, lead the class to conclude that no single solution will always protect human beings from the most extreme waves.
4. Explain that nature protects coastlines with structures such as oyster reefs. Pollution and coastal development can hinder growth of oyster reefs. But we can also create oyster reefs through devices and methods that encourage oyster growth.
5. Oyster reefs are an attractive option for coastal protection because they are relatively inexpensive and self-renewing, minimizing maintenance costs. Oyster reefs offer other benefits such as food and jobs.
6. Have the student groups list criteria for determining the relative cost of different methods of protecting coastline. Use the graphic to illustrate the basic options.
7. Have students again review the previous session and why some options are better for coastal protection than others: there is no one size fits all. Also explain that just looking at damage or high waves is not enough to make an engineering decision. Scientists must use data and models to help with decisions.
8. Show the scientist video that answers the question, [“What are additional benefits of oyster reefs besides protecting coastlines?”](#)

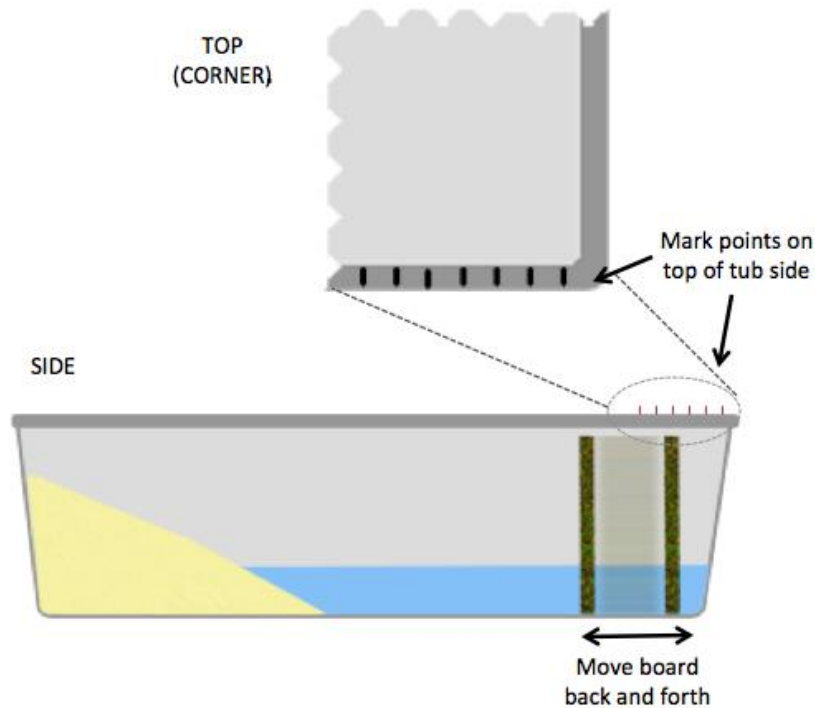
## Explore

1. Show the scientist interview video that answers the question, [“How can science help decide between oyster reefs or construction materials to protect coastlines?”](#)
2. Students use a stream table with sand and water to simulate wave action. Have students construct their wave device.

## CONSTRUCTION OF WAVE DEVICE



3. Students conduct three trials to demonstrate the extent of erosion (1) without a barrier, (2) with a narrow barrier (to simulate a small oyster reef) and (3) with a wide barrier (to simulate a more extensive oyster reef.)
4. Thoroughly wet the sand in the bucket.
5. Add enough sand to one end of the tub to come about half way up the side of the tub and about half way along the length of the tub.
6. Carefully add water to the tub. Try to disturb the sand as little as possible. Add enough water to cover about a third of the width of your sand "beach".
7. Place the Lego pieces on the sand at various distances from the "shore."
8. (Optional if digital or video camera is available). Photograph your set up from the top so you have a birds-eye view of the tub. Place the video camera on the side of the box so that you can document wave action.
9. Start the video camera (if available).
10. To create a wave, place the paver side up and lower it toward the water. Just before it is immersed in the water drop the paver the last height. This will create a wave.
11. Observe the effect of the wave, and record your observations.
12. Vary the height from which you drop the paver to vary the strength of the wave.
13. Experiment to see how high to drop the paver to start moving the sand around and "eroding" the beach.
14. Use pebbles to simulate the reef. Place the "reef" in front of the sand for the second trial. Add more pebbles to make the reef wider (trial 3).
15. Students can vary the total time the block is moved or the depth of the water to simulate different conditions such as duration of a storm or tide level.
16. Have students create a table to record their results.
17. Have students compare the effects with the paver with the effects created by continuous waves.
18. Mark points with a marker pen along the top edge of the tub. Use the ruler to ensure the points are equally spaced.
19. Use a board about the same width as the tub to create a continuous wave motion. Use the points along the top edge to ensure waves are uniform. You will not need to move the board far to get significant waves.
20. Repeat the above step moving the board a greater distance or for longer times.



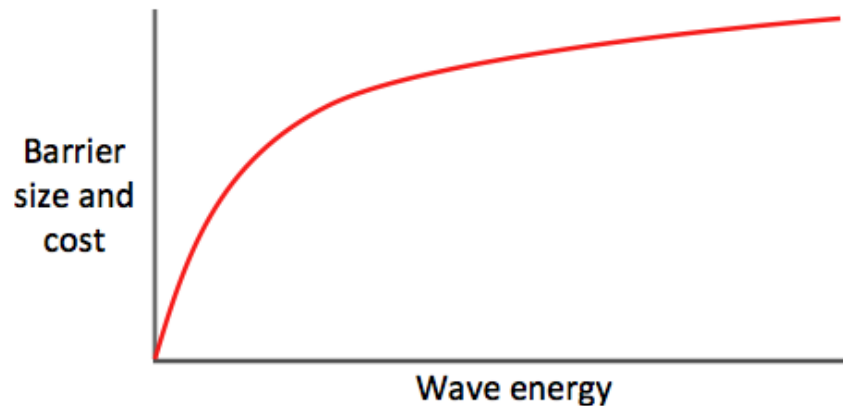
21. Have students hypothesize on the relationship between barrier cost and size, and the wave energy such a barrier will protect against. Explain to students that there is a limit to barrier cost and size, versus ever-increasing wave energy. Encourage them to think of the form of this relationship.
22. Have students form pairs to discuss why barriers prevent erosion. Have each pair present their explanation to the class. If they need help, refer them back to the first lesson, which dealt with how energy causes erosion. (They should understand that barriers absorb energy, so there is less energy to transport sand or other materials away.)
23. Show the scientist interview video that answers the question, ["Why should we use oyster reefs to protect coastlines, instead of just building the biggest seawalls possible?"](#)

### Explain

1. Students should be able to explain that there are numerous different approaches to protecting coastlines.
2. Have students form small groups in which each group describes the considerations that go into evaluating the total cost for coastal protection program. (Groups should include criteria such as material cost and strength, and amount of material needed to protect a given length of coast.)
3. Have students review their different experimental setups in terms of wave energy. They should be able to explain why a low barrier may still protect prevent erosion of the sand when waves are smaller.



- Have students describe the trade-off between the expense and size of a barrier versus the wave energy it is designed to absorb. (The larger the wave, the larger and more expensive the barrier.) However, in the long run, cost of maintenance may offset the benefit offered by higher protection.
- Have students create a graph that depicts the relationship between barrier cost and size, and the wave energy such a barrier will protect against. They don't need exact numbers, just the general idea that such a relationship would take.



#### Extend

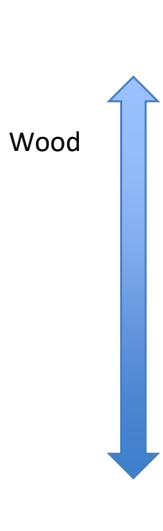
- Have students create a table with a list of benefits of oyster reefs besides protecting coastlines.
- Unlike artificial barriers, oyster reefs may strengthen over time. Ask students to brainstorm why this might be the case. (The main difference is that oyster reefs are comprised of living organisms. Over time the shells of oysters fuse, in process called accretion. An old reef comprised of mostly accreted shells is stronger than a young reef of loosely connected shells. Accretion can result in oyster reefs with a strength comparable to that of concrete.)
- Have students form small groups. Give the groups an engineering challenge to propose the best barrier to use in (a) a high energy environment and (b) a low energy environment. Have the groups use the following data to help them with their proposal.
- 

Material	Strength	Amount needed*	Cost per cubic meter
Natural Rock	30	330	\$50
Masonry	40	250	\$150
Wood	4	2500	\$25
Steel	90	110	\$225

Concrete	50	200	\$180
Oyster reef**	40	250	\$10

\*Amount needed is the amount needed to protect a given amount of coastline in cubic meters of material.

5. Have the teams account for extreme events such as storm surge. For example, the cost of repairs after a storm may be higher with more expensive materials. For the challenge, assume that in the high energy environment a barrier with strength 50 or less is destroyed every 10 years and needs to be rebuilt. The team needs to find which materials are most cost-effective over 100 years. The point is for students to understand that there is a tradeoff between protection and cost, and that in reality such calculations depend on many variables.
6. Have students create a list of why coastal erosion is an important issue, even if they live far from the ocean. For example, coastal erosion:
  - Impacts wildlife habitats, reducing habitat for coastal animals such as shore birds
  - Reduces shallow areas that serve as nurseries for fisheries that people need for food – fewer fish increases the prices of fish in stores
  - Can destroy property, reducing availability of accommodation for vacations and recreation
  - Increases siltation, which may cause coral bleaching and increase the need of dredging of seaways
  - Results in incursion of seawater into low-lying areas, increases salinity of freshwater, and thereby increasing costs of purification for drinking water and agriculture, and impacting wildlife.
7. Show students the following table:



<b>Material Strength</b>	<b>Percent Storm Damage</b>
10	100
20	50
30	33
40	25
50	20
60	17
70	14

80	13
90	11
100	10

8. Divide students into groups. Have each group devise a way to demonstrate the data in the table, and to develop a conclusion about any patterns they observe. Explain that material strength is a complex property, measured and tested in various ways.
9. Have each group brainstorm or research online ways that properties of materials can be tested to quantify strength of a material. The groups can develop ways to display this information graphically. (Groups should determine that properties of materials related to strength include compressibility, brittleness, hardness, weight, shear strength and so on. There are at least 5 main properties and 15 or more other more technical properties.)
10. Have students' list different types of material from their daily experience (wood, brick, concrete, steel, etc.) and indicate in their graphic which are relatively weak and which are relatively strong.

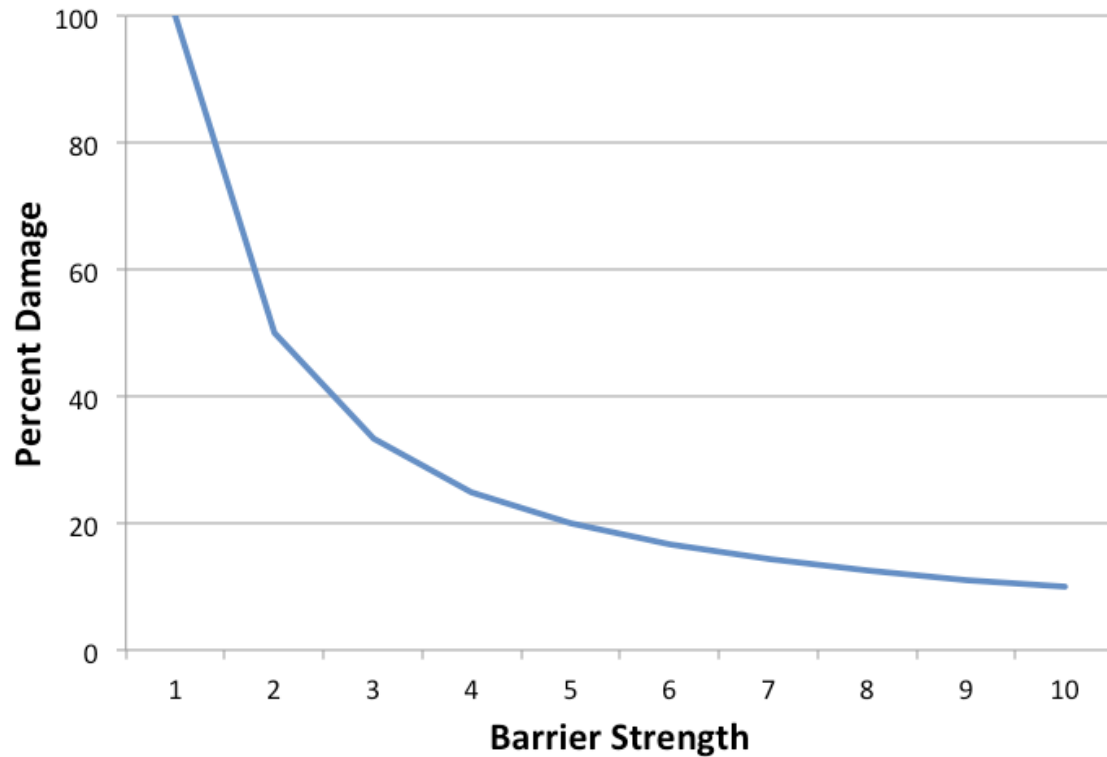
### Evaluate

Have students self-evaluate on how well they completed the hands-on activity. Did they take a systematic approach to creating waves? Did they record the data adequately? Did they understand the concept of material strength to erosion control? Specific questions:

1. What is the main purpose for using a barrier to control erosion?
2. List two advantages and one disadvantage of oyster reefs for controlling erosion.
3. When is a steel barrier a better solution for controlling erosion than an oyster reef?
4. Using the data in the table provided (Extend) section, draw a graph to show the relationship between material strength and percent storm damage. How would you characterize this graph? Show the relative strengths of wood versus steel on the graph.

### Scoring key for evaluation

1. The main reason to use a barrier to control erosion is to prevent waves removing material from shorelines. The barrier absorbs the energy of the waves, reducing the energy available to transport away coastal sand, soil and structures.
2. Two advantages of oyster reefs are that they are relatively inexpensive to construct and that over time, they actually increase in strength due to accretion. A disadvantage is that they are only appropriate in low-energy environments.
3. A steel barrier is a better solution to control erosion in a high energy environment.
4. Example graph:



This relationship is an exponential decline. That is, damage declines exponentially with strength of the barrier material.

#### **Resources and further reading**

<http://blog.nature.org/2011/03/oyster-reefs-are-in-trouble-so-can-we-still-eat-oysters/>

<http://blog.nature.org/2011/02/i%E2%80%99ll-have-the-oyster-but-hold-the-shell/>

<http://www.nature.org/ourinitiatives/regions/northamerica/areas/chesapeakebay/asian-oyster-a-risk-we-cant-afford.xml>

Scyphers, S.B., S.P. Powers, K.L. Heck, Jr., and D. Byron (2011) Oyster reefs as natural breakwaters mitigate shoreline loss and facilitate fisheries. *PLoS ONE* 6(8):e22396.  
doi:10.1371/journal.pone.0022396

### Wave Energy Calculation Worksheet

1. To determine the energy contained in a wave you will use an equation based on the height of a wave. Real-world applications use more complex formula and several variables. For this activity you will use a simplified formula.

$$\text{wave energy} = \text{wave height squared}$$

2. To determine a wave's energy, square the height of the wave

$$\text{wave energy} = \text{wave height}^2$$

3. Example calculation for a wave that is 2.5 meters high,

$$\text{Wave energy} = (2.5 \times 2.5) = 6.25$$

4. Use the following wave heights to calculate the wave energy:

Height (m)	Wave energy (= Wave height <sup>2</sup> )
0	
0.1	
0.5	
1.25	
2.5	
4	
6	
9	
14	

### Description of Different Sized Waves

Height (m)	Description
no wave	Calm (Glassy)
0 - 0.10	Calm (Rippled)
0.10 - 0.50	Smooth
0.50 - 1.25	Slight
1.25 - 2.50	Moderate
2.50 - 4.00	Rough
4.00 - 6.00	Very Rough
6.00 - 9.00	High
9.00 - 14.00	Very High
14.00+	Phenomenal

5. Draw a graph showing the wave energy for the different sized waves in the table.

## Lesson 4: The Blackbeard Connection: Barrier Islands as Part of and Protection for the Wetlands

(Modified from:

<https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbmxncmFtdmFsaXNsYW5kfGd4OjRkZGMzNDNIN2NjNmQ5YmY>)

This lesson is an adaptation of “The Fragile Fringe” created by The National Wetlands Research Center of the USGS. The original lesson can be found on <http://www.nwrc.usgs.gov/fringe/barriers.html>

### Objectives:

1. To identify the barrier islands as part of the wetlands
2. To show the value of the barrier islands to the wetlands

### Engage:

Students will enter the classroom/ learning center and view the following images on the overhead. They are asked to record what they think they are seeing in each picture, what observations they can make, what they can infer about what the topic of the day is. They must create one question that they have about the images using a higher order thinking question stem.



Next, students will share their questions with their classmates who will be challenged to answer each as a class.

Materials: computer with overhead, paper, pencils

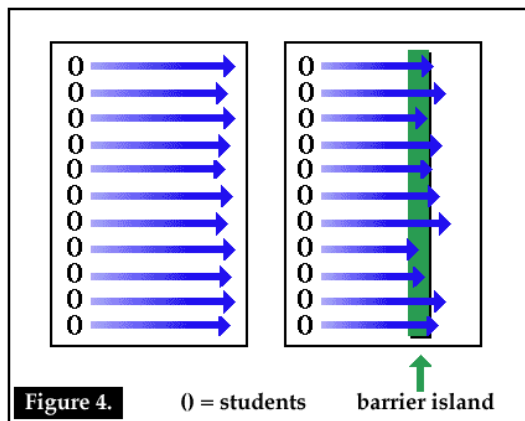
Time: 30 min.

### Explore:

#### Activity:

1. Line students up on one side of the classroom (Fig. 4). They will represent an incoming wave or strong wind. Have them move as a group across the room and record the time it takes for them to cross the room. Next, set up a barrier of cardboard boxes, chairs, cement blocks, or boards (anything that is available and not dangerous to the students). This time, they must cross the room and go *across* the barrier. Record the time it takes for them to travel the same distance.

2. Discuss why it took them longer to cross the room the second time and how this phenomenon can positively affect the coastal wetlands. Ask the students about the type of organisms, plants in particular, that must inhabit the barrier islands. This might include ideas about how they are anchored so that they can withstand the wind and wave action as well as the fact that they are relatively small and shrubby.



Materials: Open room, obstacles (If you are in CBSP, the learning center is a great place to do this activity. The table and chairs in the front of the room can be easily used for obstacles)

Time: 30 min.

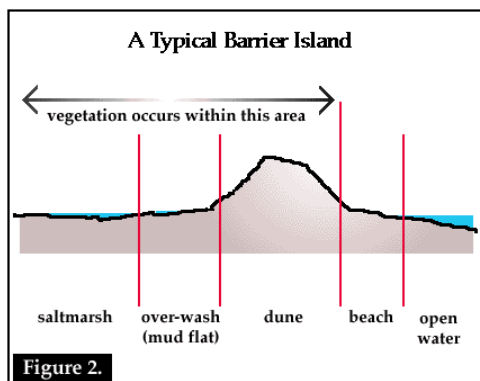
#### Explain:

Students will be shown the same images from the “Engage Activity.” They are to first be asked to explain the images in their own words using the observations of the “Explore” simulation. At the images below, ensure that the following content is understood. Depending upon ability, grade, and prior knowledge level, this can be accomplished through guiding and scaffolding either by leading questions, connections to prior knowledge, or a combination of the previous with direct instruction.

*Extension- Teachers can prepare a “Sightseeing Tour” of the Georgia Coast using Google Earth ahead of time. Using this feature you can highlight relevant areas of interest and even record audio and then play back at any time.*

Although barrier islands, called spits in the northeastern United States, exist on all coastlines, they are most notable along the Gulf of Mexico and Atlantic coasts.

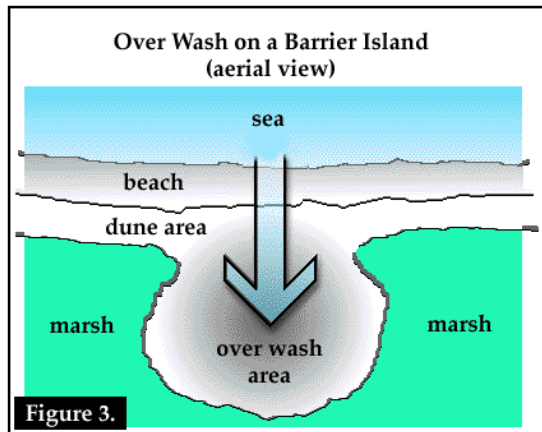
Learning Objective for Figure 2:





They are the structures resulting from the movement of sediments by wind and the currents. The seaward side of a barrier island is usually a sandy, beach-like area (Fig. 2). This area increases and decreases in size with changes in seasonal wind and wave action which carries sand into and away from the sandy shore.

Learning Objective for Figure 3:



The area behind the beach is an area of dunes and then a mud flat or over-wash area created when the waves breach a low area of a dune (Fig. 3). The dunes contain plants that stabilize the system by trapping sand that would otherwise be blown away. The flat is wet and may be completely flooded during storm surges and extremely high tides. Beyond the flat is a salt marsh. These islands, as obstacles, slow down the waves and winds associated with strong storms and hurricanes that impact the coastal areas. They also provide a habitat for a many of the same species found along the coastal marshes.

Materials: "Images to Engage" document, computer with overhead, same notes as "Engage activity" to add to, pencils

Time: 45 min.- 1 hr.

### Extend:

Students are given an option of possible extension activities:

- Have students research and set up a demonstration to show why waves "break" as they reach the shore. (Kinesthetic learners, learning by "doing")
- Let the students find out why dunes with plants on them are generally larger than those without plants (give them a hint about carrying capacity of the wind at different speeds, if they need help). They must use data to create a graph that illustrates their findings. (Spatial intelligence, Math integration)
- They may also research the formation of the barrier islands - explain why the sand was deposited there to begin with as well as how barrier islands "move." They must write a paper that communicates their research. (verbal intelligence, L. Arts integration)
- They may research the movement of the barrier islands and make a visual presentation of the future of the islands in a particular location. They should utilize both Army Corp of Engineer

historical data and Google Earth in their presentation. (Differentiation for high ability/ motivation)

Materials: Students must provide a list of materials needed for option a, computer with internet access and Excel and Word (or similar programs)

Time: 2- 3 days; students should be given time in class to plan and choose an assignment with their partner (Report choice and plan to teacher by end of Day 1),

**Evaluate:** Students will be assessed in two ways during this lesson:

1. Meaningful Participation in the Engage and Explore Activities
2. Evaluation of the product of the Extend activity

## Lesson 5: Coastal Erosion...What can we do?

([www.cpalms.org/uploads/resources/13474/Big\\_Idea\\_6\\_Coastal\\_Erosion\\_Grade\\_4.docx](http://www.cpalms.org/uploads/resources/13474/Big_Idea_6_Coastal_Erosion_Grade_4.docx))

### **OBJECTIVE**

The student will design a process to slow down coastal erosion of beaches using the engineering design process.

### **MATERIALS**

Large aluminum pans/trays

Sand, sandbox quality

Toy monopoly houses

Fabric strips, 8" X 1" strips

Wire mesh strips, 8" X 1" strips

Clay

Pipe cleaners

Pantyhose, 8" X 1" strips

Scissors

Paint mixing sticks

Goggles

Newspaper

Rulers

### **DESIGN CHALLENGE**

#### **SESSION ONE**

#### **ASK**

##### **Background Statement/Real World Scenario**

Georgia and Florida are defined by their beaches. They are arguably our most important natural resource. But our beaches are losing more and more sand each year, as a result of inlets and jetties, erosion causing hurricanes, and slowly rising sea levels. The maintenance of beach nourishment, which means to refill sand where it has been eroded, is very expensive and an engineering solution must be developed to prevent further damage.

### Challenge Statement

Design a way to slow down the process of erosion, without damaging the coastal ecosystem, after twenty set of wave activity.

Ask students what information that would need to know in order to complete this challenge.

Sample questions include:

*Who is your client?*

*What do we need to create?*

*How does this relate to what we learned in the last essential lab on wind?*

*What have others done to solve this problem?*

*What are your constraints/ limitations?*

*Individuals in what type of career would work to solve a problem like this?*

### **IMAGINE**

Brainstorm as a class before you introduce the materials. What possible solutions exist to this challenge? What other things have been tried on the Atlantic Coast to prevent erosion:

### **DESIGN**

1. Divide students into engineering teams of four.
2. Introduce materials table to students. Identify and name all materials on the table. Remind students that the only materials that are available are on the table. They may not use any additional materials. .
3. Inform students that you will be acting as the Project Manager for their engineering firm. As Project Manager you require that each engineering team submit their blueprint design before they can request any materials.
4. Give students about ten minutes to create and label a scale drawing of their product. Remind students that they must estimate how much of each material they need; so that their group receives only the amount they need to cut down on waste. Student teams will only be able to shop once in their initial design and once during their re-design.
5. Sign off on design blueprints before students are able to create their initial product.

## **SESSION TWO**

### **CREATE**

1. Review the design challenge.
2. Explain that students must develop their own working erosion blocking process/ product from everyday items that will prevent erosion after 20 sets of wave activity.
3. Remind students that their process should not disrupt the ecosystem which would include eliminating feeding patterns, introducing new animals, or excess pollutions
4. This design challenge has several constraints:
  - a. Everyone must have exactly three inches of “beach” out of the water and no more to start.
  - b. 1.5 inches of water will be used as the ocean.
  - c. All waves will be created by the teacher lifting the pan opposite the beach, 1 inch off the table and putting it back down twenty times.
5. Now that designs have been created, it is time for the engineering design teams to build their product/ process.
6. Assign a team leader to every group. Ask the team leader to assign a job to each member of the group.
7. Ask one member of each group to bring their design blueprint to the material store. Give students the amount of each materials requested. Remind them that they can only shop once for their initial design.
8. Give students 20 minutes to create their prototype.
9. Label each completed product with a letter for identification during testing.

### **TEST**

1. Students will now conduct a guided inquiry as a class to test the effectiveness of their product.
2. Encourage students to use the scientific process.
3. Ask students to formulate a hypothesis. This is a class inquiry so students will choose which group’s product they believe will perform the best, when compared to the other products in the class.
  - a. If Georgia/Florida chooses Product \_\_\_ to reduce coastal erosion, then it will be the most efficient because\_\_\_\_\_.
4. Identify variables. What are we measuring? What is changing? What is remaining constant?

5. Have students prepare a data table. A sample is provided below. It is a good idea to prepare a class data table as well.
6. Each team will follow the steps below.
  - a. The teacher will lift the pan opposite the beach, 1 inch off the table and putting it back down twenty times under document camera or in an area where other students can view.
7. Repeat two additional times.
8. Analyze data. Was the design effective in preventing erosion?

Team Name:	Trial One Observation	Trial Two Observation	Trial Three Observation	Design Sketch
Initial Design				
Re-Design				

### **RE-DESIGN**

1. Remind students that they can re-design their product to make it better and that this represented only their first trial. In engineering, a first trial is like a first draft in writing is can be adapted to meet the needs of your audience/ client.
2. Ask students what they would improve. Have students work in their engineering groups for ten minutes to re-design their product. They should not start over but adapt their current design.
3. Then, students can request additional materials and spend ten minutes re-creating/ adapting their product.
4. Students should re-conduct the test as class as listed in steps #1-8 above.
5. Create a class data table and compare results.
6. Why were some designs more successful than others?

### **REVIEW CONTENT**

After students have completed the design challenge, build on what they have just observed to tie it to content. Remind students that they have been learning about erosion and our ability to prevent it.

Remind students that erosion is the process of moving weathered materials and that the accumulation of the weathered and eroded materials is called deposition.

1. How did the results of this design challenge compare to the results from the other investigations in this unit?
2. How would severe weather effect coastal erosion?
3. Is coastal erosion dependent upon location?

### **VOCABULARY**

Now that students have completed the activity and made content connections it is time to connect it the vocabulary. Make certain that you associate each word to a different aspect of the design challenge that the students undertook.

1. Ask students if we saw erosion and weathering at work in this design challenge?
  - a. Discuss and define.
2. Where else might you see erosion and weathering at work in our community?
3. Review the terms:
  - a. Erosion
  - b. Levee
  - c. Weathering
  - d. Coastal
  - e. Environmental Engineer
  - f. Wave
  - g. Jetty
  - h. Resource
  - i. Dependent Variable
  - j. Independent Variable

## CONNECT TO THE ENGINEERING DESIGN PROCESS

Engineering involves systematically working to solve problems. To do this engineers employ an engineering design process which works hand in hand with the engineering design process. Help students to identify when they complete the following steps in today's design challenge:

- Ask
- Imagine
- Design
- Create
- Test
- Re-Design

1. Ask students why the engineering design process is a cycle.
2. Compare and contrast with the engineering design process with the scientific method.

