Who Moved the Beach?

Below is an overview of the activity Who Moved the Beach? (NANOOS) to incorporate information learned from Dr. Herrington's presentation and subsequent discussion.

Lesson Overview

Students learn about the primary causes and impacts of coastal erosion and how human communities respond to these shoreline processes.

Lesson Rationale

Coastal erosion and accretion are major components of coastal management throughout the United States. By studying these processes students are exposed to both Physical Science and Earth & Environmental Science concepts through a case study that many can relate to, as so many students have visited the shore in the summer. First, students will identify coastal erosion as a natural process, and explain how human activity can increase the risks associated with coastal erosion. Then students will identify options for reducing risks caused by coastal erosion, and discuss the advantages and problems associated with these options. Finally, students will analyze and interpret beach elevation data, and make inferences from these data about the relative vulnerability of different beaches to coastal erosion.

Key Concept

Students explore the primary causes and impacts of coastal erosion, and how human communities' can/should respond to the processes.

Adjustments to Write-up

Links to Overview Essays and Resources Needed for Student Research

The second website is no longer live, but the NOAA Ocean & Coastal Resource Management Coastal Program website (http://coastalmanagement.noaa.gov/programs/czm.html) contains good information.

Learning Procedure

In the note section, to show students images of severe coastal erosion visit http://www.photolib.noaa.gov/nws/index.html (the other website is incorrect). Scroll down to "Historical National Weather Service ~ Albums" and select "Meteorological Monsters." If interested in hurricanes specifically, scroll down to the Hurricanes section to select which album you are interested in sharing with the students.

In step 3, we have provided the data file ("who_moved_the_beachdata.txt") to use in the activity.

In step 4 in the second paragraph, the example of renourishment is no longer an active link. Instead visit http://www.csc.noaa.gov/magazine/2002/04/beach.html for a case study of beach renourishment from a town in Long Island.

The Me Connection

To access the full report, the correct URL is now www.epa.gov/climatechange/effects/downloads/takings.pdf.

Extensions

To access information about how to build and use a stream table, the correct URL is now www.mostreamteam.org/Documents/how_to/streamtable.pdf.

Resources

To access the National Coastal LIDAR data visit http://www.csc.noaa.gov/digitalcoast/data/coastallidar.

I was unable to find an active link for the "Beach Nourishment: A Guide for Local Government Officials."

To access the summary of the "Evaluation of Erosion Hazards" report, visit http://research.fit.edu/sealevelriselibrary/documents/doc_mgr/455/US_Erosion_Hazards_Summary_-_Heinz_Ctr._2000.pdf. To access the full report, visit http://www.fema.gov/pdf/library/**erosion**.pdf.

COASTAL MANAGEMENT LESSON PLAN

Who Moved the Beach?

NOS Topic
Coastal Management

Theme
Shoreline Erosion

Links to Overview Essays and Resources Needed for Student Research
http://www.oceanservice.noaa.gov/topics/coasts/assessment/
http://coastalmanagement.noaa.gov/pcd/coastal_hazards.html

Subject Area
Earth Science

Grade Level
9-12

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

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

Materials Needed
- (optional) Computers with internet access; if students do not have access to the internet, download copies of materi-

als cited under "Learning Procedure" and provide copies of these materials to each student or student group
- Copies of "Coastal Erosion Subject Review Worksheet," one copy for each student or student group
- Graph paper or computers with spreadsheet and graphing software

Audio/Visual Materials Needed

None

Teaching Time

One 45-minute class period, 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/htm/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/historic/nws/*.

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 <u>rivers and streams</u>, and also comes from <u>weathering of exposed rock formations</u>, and from <u>the deterioration of shells, corals, and skeletal fragments</u>.

(2) Coastal erosion is a natural process that removes sediment from shorelines. Another natural process that deposits sediment on shorelines is known as <u>accretion</u>.

(3) Sand is generally moved offshore by high-energy waves during <u>winter</u> months, and is returned by gentle waves during <u>summer</u> 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 Overwash 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 th 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 th 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 can be found at *http://www.vims.edu/bridge/beachgraph.html*. There are three changes needed to these instructions:

(a) use the "threebeaches.txt" file instead of "beachdata.txt";
(b) be sure that the format specified in "File Origin" (step 1) matches the operating system that your students are using; and
(c) be sure students adjust the size of the first row so that the entire label can be read.

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

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

http://www.vims.edu/bridge/ – In the "Site Navigation" menu on the left, click on "Ocean Science Topics," then "Marine Geology" for links to resources on 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/pdfs/bldusng.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 Infocenter).

Resources

http://www.csc.noaa.gov/crs/rs_apps/sensors/lidar.htm – National Coastal LIDAR data from NOAA's Coastal Services Center *http://ww3.csc.noaa.gov/beachnourishment/* – Beach Nourishment: A Guide for Local Government Officials from the NOAA Coastal Services Center

http://www.heinzctr.org/NEW_WEB/PDF/erosnsum.pdf and *http://www.heinzctr.org/NEW_WEB/PDF/erosnrpt.pdf* – summary (23 pages, 544 kb) and full (252 pages, 3.9 mb) report, "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 – CNNfyi article, "Beaches on the brink"

National Science Education Standards

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science
- Motions and forces
- Interactions of energy and matter

Content Standard D: Earth and Space Science
- Energy in the earth system
- Geochemical cycles

Content Standard E: Science and Technology
- Abilities of technological design

Content Standard F: Science in Personal and Social Perspectives
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Links to AAAS "Oceans Map" (aka benchmarks)

5D/H3 – Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

COASTAL MANAGEMENT REVIEW SHEET

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://www.heinzctr.org/NEW_WEB/PDF/erosnsum.pdf*

"Mapping Coastal Change Hazards" U.S.G.S. website beginning at *http://coastal.er.usgs.gov/hurricanes/mappingchange/*

"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 __________.