

Oceans - Coastal Hazards: Hurricanes, Tsunamis, Coastal Erosion



GRADE SCHOOL

EARTH CRUST

U.S. Department of the Interior

USGS
science for a changing world

NTA

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

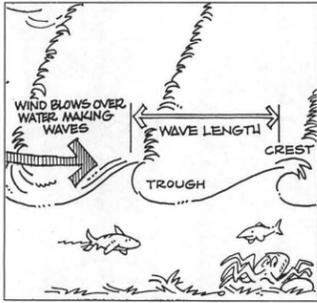
IPED
INTEGRATED PROJECT 2000+

Oceans are the largest geographic feature on the surface of the Earth, covering approximately 70% of the planet's surface. As a result, oceans have a tremendous impact on the Earth, its climate, and its inhabitants. The coast or shoreline is the boundary between ocean environments and land habitats. By the year 2025, it is estimated that approximately two-thirds of the world's population will be living within 200 kilometers of a coast. In many ways, we treat the coast just like any other type of land area, as a safe and stable place to live and play. However, coastal environments are dynamic, and they constantly change in response to natural processes and to human activities.

Storms can change the shape of the shoreline and destroy buildings, roads, and homes. Flooding along the coast can occur during storms especially when high tides combine with large waves to raise sea level. This is called a storm surge. Catastrophic events such as hurricanes or tsunamis can greatly modify the shape of coastal areas, cause major flooding, destroy property, and take lives. The sediment that forms a beach, or dune, can come from rivers, cliff erosion, waves, or currents that flow along the shore (longshore current). Waves, currents, and storms can also remove or erode coastal sediments. Extensive beach erosion can cause buildings to collapse into the ocean and dramatically change the nature of the shoreline.

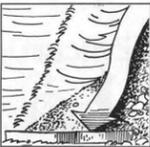
In recognition of the importance of the ocean and the need to sustain our greatest common global heritage, the United Nations declared 1998 the Year of the Ocean. The idea for the Year of the Ocean, which will be celebrated around the world, was originated by the Intergovernmental Oceanographic Commission (IOC) in 1993. As one of many contributions to the Year of the Ocean, this poster is designed to describe several natural processes or events that can change the shape of the coast and affect nearby environments. Coastal erosion, flooding, and the effects of hurricanes or tsunamis are all considered coastal hazards. The causes of these hazards and community preparations and responses to the hazards are depicted here. This poster is folded into 8.5" X 11" panels; front and back panels can easily be photocopied for educational use.

Tides and Waves



Tides rise and fall in response to the gravitational pull of the Sun and the Moon. High and low tides occur each month when the Sun and Moon align. Tides help determine where waves break on the shore—low on the beach at low tides, and high on the beach at high tides. Most waves are created by winds. The size of a wave depends upon the force of the wind (magnitude), the length of time the wind blows (duration), and the amount of open water over which the wind can blow (fetch). Although waves look as if they move horizontally through water, they actually are the vertical (up and down) movement of water. The highest point of a wave is the crest. Between the crests of two waves is a low point, called the trough. The height of a wave is the distance from the trough to the crest. As waves get closer to shore, depths tend to become more shallow, causing waves to break. In the ocean, there are many waves moving in different directions at the same time. Storm systems and movement on the ocean floor can create waves up to 30 meters high.

Coastal Erosion



Coastal lands are constantly changing through erosion and deposition. Waves are the primary cause of coastal erosion. The larger the waves, the greater their erosive power; thus, storm-generated waves cause the greatest coastal erosion. Breaking waves can undercut cliffs and break down rocks and sediments into smaller and smaller pieces. Waves can also cause barrier islands to erode and move landward. Because breaking waves do not always approach the coast straight-on, longshore currents can form along the coast, flowing in the direction of wave movement. Sediment moves gradually along the coast until an obstacle, such as a jetty, is encountered. Water flow is slowed and the sediment is deposited. Rivers can carry new sediments to the coast, building deltas and widening beaches.

Hurricanes



Hurricanes form in areas of low atmospheric pressure over warm ocean water. As warm air rises and expands, winds near the ocean surface spiral, bringing in more humid air that continues to feed the storm. As the storm grows, atmospheric pressure drops and wind speed increases. If the wind speed exceeds 119 kilometers per hour (74 miles per hour), the storm is called a hurricane. Hurricanes can bring high winds, flooding, and excessive rain to the coast. Because scientists can estimate a hurricane's strength and where it will strike, there can be time to warn at-risk communities. Preparations for a hurricane include clearing all loose objects from around homes, buildings, and yards; boarding windows; storing drinking water and nonperishable food supplies; planning evacuation routes, and possibly even evacuation.

Tsunamis



A tsunami is a series of waves spreading rapidly in all directions from a disturbance on the ocean floor. The most common source of tsunamis is earthquakes. Earthquakes are produced by the sudden movement of the Earth's crust. Unlike waves produced by winds, which travel only on the surface of the ocean, tsunamis travel through the entire depth of the ocean waters. The speed of a tsunami depends on water depth; in the deep ocean, a tsunami can travel at the speed of a commercial jet plane. When a tsunami reaches the coastline where water becomes shallow, the waves slow down and their energy is compressed, causing them to build as high as 30 meters. Tsunami waves and resulting flooding can cause property damage and loss of life in low-lying areas. Most tsunamis occur in the Pacific Ocean. Because of this danger, the International Tsunami Warning System was created to warn people in countries around the Pacific Ocean of tsunami danger. When a major earthquake occurs, scientists identify the earthquake's size and location by using seismographs located around the world. If the earthquake is large enough and is located near the ocean, a tsunami warning is issued to potentially affected areas. The progress of the tsunami is monitored by water-level gages located along the shorelines of continents or islands or by instruments placed on buoys in mid-ocean.

ACTIVITY

Coastal Erosion

INTRODUCTION

Coastal lands, which include cliffs and beaches, are constantly eroding. Coastal erosion is difficult to predict and almost impossible to stop. Waves are the primary energy source that causes coastal erosion. Most waves are created by winds blowing across the surface of the ocean. Large storms generate destructive ocean waves. Waves breaking at the base of cliffs can cause them to erode and collapse. When waves break at an angle to the shore, they can create longshore currents, which transport sediments along the coast. Sediments can be eroded from one location and deposited in another. Coastal erosion depends on the stability of shoreline sediments, the intensity and frequency of storm waves, and the exposure of coastal lands. The following activity is designed to help students understand coastal erosion caused by waves.

OBJECTIVES—Students will:

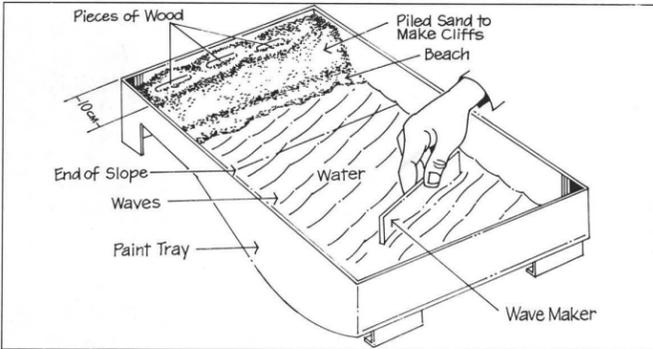
1. Model and observe how waves affect the movement of sand and erode cliffs on a coastline.
2. Observe how coastal erosion can affect buildings constructed along the coast.
3. Observe the difference in erosion caused by different size waves.

MATERIALS—Each group of three students will need:

1. One large paint tray or large rectangular container at least 35 cm by 28 cm.
2. 1 liter of moist sand.
3. 600 milliliters of water.
4. One 15-cm-long wavemaker. One-half of a 30-cm ruler or paint stir-stick works well.
5. Paper and pencil.
6. A metric ruler.
7. Three 2.5-cm pieces of wood.
8. One 12- to 15-liter container for cleaning sand.

TEACHER PREPARATION

1. This activity is designed for students to work in groups of three.
2. Display a copy of the poster titled "Oceans—Coastal Hazards: Hurricanes, Tsunamis, Coastal Erosion" on the classroom wall several days prior to conducting this activity.
3. Obtain approximately 10 liters of play sand, (1 liter for each group). This sand can be obtained from most garden or hardware stores or it can be collected at a beach. Thoroughly wash the sand in a 12- to 15-liter container until the rinse water is mostly clear. Collect all of the materials needed by each group. Cut paint stir-sticks or plastic rulers (wavemaker) in half so that there is one for each group. The 2.5-cm pieces of wood are used to represent houses or buildings.
4. Assemble one of the models and try the activity prior to presentation to the students. (See Example.)



INTERPRETIVE QUESTIONS

Conduct a class discussion concerning coastal erosion. Using the diagrams for reference, solicit answers to the following questions:

1. Compare diagrams from steps 2 and 3. Was there any change in the shape of the beach and the dunes or cliffs? What happened to the houses or buildings? Describe these changes and their cause.
2. Compare diagrams from steps 2 and 4. Was there any change in the shape of the beach and the dunes or cliffs? What happened to the houses or buildings? Describe these changes and their cause.
3. In which direction did the sand move; that is, in which direction was the longshore current moving?
Answer: Along the beach at an acute angle to the waves.
4. Each group should give a presentation describing what happened to the coastal landscape and the houses and buildings they placed on it. Students should use the three diagrams as references to show changes in the coast resulting from the waves. Ask each group if they would live in one of the houses at the location they chose on their model. Have them explain their answers.

EXTENSION

Instruct students to research coastal storms and hurricanes. Through the research, students should answer the following:

1. Where do most of the major storms occur?
2. List three major storms and the location where each occurred.
3. What methods would students recommend for preventing loss of life and property from major storms?

PROCEDURE

1. Divide the class into groups of three. Provide each group with a paint tray or large rectangular container, 1 liter of sand, 600 ml. of water, one wavemaker, three 2.5-cm pieces of wood, one metric ruler, and a pencil and paper.
2. Have the students pour about one-half of the sand into the container, spreading it evenly over approximately three-fourths of the sloping part of the paint tray from the top edge down. If using a large rectangular container, the students should spread the sand to cover about 15 cm along the long side of the container. This side of the container should then be elevated approximately 2.5 cm. The sand represents a sandy beach. The open area of the paint tray or container will be filled with water, representing the ocean. Have the students add the remainder of the sand to the top of the container to form dunes or cliffs. These landforms should be approximately 2.5 cm high and should not extend more than 10 cm from the top of the paint tray or 7 cm from the top of the rectangular container. Have the students place the 2.5-cm pieces of wood any place they choose in their model. Inform the students that the wood pieces represent houses or buildings. Add approximately 600 mL of water to the bottom part of the pan where there is no sand. Students should draw a diagram of their model, including the width of the beach, the width of the cliffs or dunes, and the location of the houses or buildings.
3. Have each student take turns creating waves in the model ocean, holding the wavemaker horizontally and using it to make waves. Students should use a sharp, short, pushing motion with the wavemaker, pushing the wave at one corner of the container, at an angle to the beach. This set of waves should be small, breaking on the beach below the cliffs or dunes. Each student should make approximately 20 waves. After each student has taken a turn making waves, have them make a second diagram of the beach, measuring the width of the beach and dunes or cliffs and locating their houses or buildings. Have students then compare "before-and-after" diagrams. Has there been any movement and deposition of sand along the beach?
4. Again, each student should take a turn making waves as described in step 3, except this time students should make waves large enough to touch the cliffs or dunes. These larger waves represent waves created from large storms or hurricanes. After each student has taken a turn making waves, have students make a third diagram of the coastal lands. Be sure that the students measure the length and height of the cliffs and dunes on the diagram and the locations of the houses and buildings so that they can compare them to the first diagram.

DEFINITIONS

Atmospheric pressure - The weight of Earth's atmosphere. Atmospheric pressure is usually measured in inches of mercury with normal pressure raising a column of mercury 29.92 inches (76.0 cm). Measurements above 29.92 inches of mercury are considered high pressure and measurements below are considered low pressure.

Delta - A deposit of sediment at or near the mouth of a river.

Erosion - Process whereby materials of the Earth's crust are loosened, dissolved, or worn away and moved, usually by water or wind.

Hurricane - An atmospheric low-pressure system with a circular motion, counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere, with wind speeds equal to or greater than 119 kilometers per hour (74 miles per hour).

Jetty - An engineered structure designed to direct currents or tides.

Longshore current - An ocean current that flows parallel to the shore and is caused by waves approaching the coast at an angle.

Sediment - Particles derived from rock or organic materials that have been transported by water or wind.

Storm surge - An abnormal rise of the ocean along a shore as the result of storm-generated winds.

Tides - The rise and fall of the ocean caused by the gravitational pull of the Moon and Sun.

Tsunamis - A series of waves spreading rapidly in all directions from the area on the ocean floor where a large earthquake, volcanic eruption, or landslide has occurred.

Water wave - A disturbance in water that transmits energy from one place to another. In the ocean, the most common cause of this disturbance is wind.

Wavelength - The distance between the crests of two successive waves.

Wave height - The vertical distance between a wave crest and the preceding trough.

Wave trough - The lowest part of a wave, between successive crests.

ORDERING INFORMATION

Copies of the other posters in the series (see Poster Series Panel) and the Oceans poster (color for grades 3-5 and 6-8 or black-and-white) can be obtained at no cost from the U.S. Geological Survey. Write to the address below and specify the poster title(s) and grade level(s) desired. A limited number of color and black-and-white posters entitled "Water: The Resource That Gets Used & Used for Everything" are also available in Spanish by writing to the address below.

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver Federal Center
Denver, CO 80225
Telephone: (800) 435-7627

Poster Series

This poster is part of a series of water-resources education posters developed through the U.S. Geological Survey's Water Resources Education Initiative, a cooperative effort between public and private education interests. Partners in the program include the U.S. Geological Survey, Bureau of Reclamation, and the U.S. Fish and Wildlife Service of the U.S. Department of the Interior; the National Oceanic and Atmospheric Administration; the U.S. Environmental Protection Agency; the U.S. Army Corps of Engineers; the Nebraska Groundwater Foundation; and the National Science Teachers Association.

The other posters in the series are entitled "Water: The Resource That Gets Used & Used for Everything!", "How Do We Treat Our Wastewater?", "Wetlands: Water, Wildlife, Plants, & People!", "Ground Water: The Hidden Resource!", "Water Quality: Potential Sources of Pollution", "Navigation: Traveling the Water Highways!", "Hazardous Waste: Cleanup and Prevention", and "Watersheds: Where We Live." The posters in the series are designed to be joined to create a large wall mural. A schematic of the wall mural is displayed on this panel. The gray shaded spaces represent the posters listed above. The black shaded space represents this poster.

OCEANS	WATERSHEDS	HAZARDOUS WASTE
WETLANDS	WATER USE	WASTEWATER TREATMENT
NAVIGATION	GROUND WATER	WATER QUALITY

Water-resources topics of the posters are drawn in a cartoon format by the same artist. Posters are available in color or black and white. The reverse sides of the color posters contain educational activities: one version for children in grades 3-5 and the other for children in grades 6-8. The black-and-white posters are intended for coloring by children in grades K-2.

ACKNOWLEDGMENTS

The following individuals and organizations contributed to the development of this poster:

Project Chief, Principal Author, and Layout: Stephen Vandas, U.S. Geological Survey, Denver, Colorado

Project Coordinator: Lynne Merstfelder, National Oceanic and Atmospheric Administration

Art Work: Frank Farrar, Frank Farrar Graphics, Denver, Colorado, under contract to the National Science Teachers Association.

U.S. GEOLOGICAL SURVEY (USGS)

The USGS provides the Nation with reliable, impartial information to describe and understand the Earth. This information is used to minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; enhance and protect the quality of life; and contribute to wise economic and physical development. The USGS proudly serves the Nation in providing "science for a changing world."

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

The NOAA's mission is to describe and predict changes in the Earth's environment and to conserve and manage wisely the Nation's coastal and marine resources to ensure sustainable economic opportunities. The NOAA is committed to a 21st century in which environmental stewardship, assessment, and prediction serve as keystones to enhancing economic prosperity and quality of life, better protecting lives and property, and strengthening the United States balance of trade.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC, AND CULTURAL ORGANIZATION (UNESCO)

The purpose of UNESCO is to contribute to peace and security by promoting collaboration among nations through education, science, and culture in order to further universal respect for justice and for the human rights and fundamental freedoms which are affirmed for the peoples of the world, without distinction of race, sex, language, or religion by the charter of the United Nations. Project 2000+ aims at achieving scientific and technological literacy for all and is implemented by the Science & Technology Education Section of UNESCO.

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (IOC)

The IOC of UNESCO is an agency established in 1960 to promote scientific marine investigations and related ocean services with a view to learning more about the nature and resources of the ocean through the concerted actions of its 125 members. The IOC plays a pivotal role in expanding knowledge about the world's oceans and improving international capabilities through a commitment to coastal and oceanographic research, systematic ocean observations, technology development and transfer, and related education and training.

Grade School