Beach in a Pan

Topics
Sand, Waves

Grades
3-5

Site
Indoors

Duration
30-45 minutes

Materials
See page 2

Vocabulary
berm, groin, profile, sediments, transect

Next Generation Science Standards

Practices
Developing and using models
Core Ideas
PS4.A Wave properties ESS2.A Earth materials and systems
Crosscutting Concepts
Patterns
Performance Expectations
See page 5

Focus Question

How do waves shape beaches?

Overview

Students construct a beach in a pan and investigate the effects of wind and waves on beach shape. Students investigate and sequence sand grain sizes, create various beach profiles and examine issues associated with coastal development.

Objectives

Students will be able to:

- Explain how wind and waves transport sediment.
- Identify variables (beach slope, wave size and frequency, angle of waves hitting beach) that influence the shape of a beach.
- Describe pros and cons of building on coastlines.

Background

A beach is a dynamic system. It is a river of moving sand and a place where **sediment** is constantly being transported and deposited. Sediment is transported and deposited by wind, waves and currents. Beaches are found in places suited to sediment deposition, like calm areas between rock outcroppings, shores sheltered by offshore islands and regions with moderate surf.

A variety of sand grain sizes are usually found on a beach. The finest grains are often found furthest from the water. That's due to wind blowing and transporting fine grains up the beach. When a wave hits the beach, much of the wave energy is lost. The largest sediments drop out first and are deposited higher on the beach. The lighter sediments remain in suspension a bit longer and fall out as the wave recedes. The lightest sediments are carried back out to sea and may eventually settle out beyond the surf line. Therefore the largest particles are often found between the low tide mark and the **berm**, with smaller particles found either offshore or higher up on the beach.

Beach slope is influenced by the size of sand grains and the waves. Coarser sediments tend to produce a beach with a steeper slope. Conversely, a beach with finer sediments tends to be flatter. The force and size of waves influences the beach composition, too. Stronger waves are able to carry away larger particles when they recede, while calmer areas tend to deposit more sediments on the beach and produce a steeper slope. This means that areas with stronger waves tend to be flatter and areas with calm waves tend to be steeper. Since the strength of waves can vary seasonally, the slope of a beach may also vary seasonally.

Many beaches share a typical **profile**, though it will vary seasonally. Dunes, cliffs or seawalls are often the area farthest away from the water. Berms are found closer to the water. This is an area where sediment has accumulated parallel to the shore. It is the farthest place where sand is deposited by waves on the beach. The area between the berm and the low tide mark is the intertidal. This is the active zone of the beach where waves crash during the daily rise and fall of the tides.

The dynamic nature of sand can result in challenges to coastal development. With most of the world's population living on the coast, new homes and businesses are built every year in coastal areas. Millions of dollars each year are invested in protecting structures from the natural process of coastal erosion.

Breakwaters, **groins**, jetties and sea walls are all physical structures used to protect structures from strong waves and prevent the erosion of sand. Breakwaters, structures in the water parallel to the shore, prevent the longshore current from moving sand so sand may accumulate and need to be dredged to keep harbors functional. Groins, structures extending from the beach perpendicular to the coast, often result in the erosion of sand on the downdrift side. Jetties are similar to groins but are used to stabilize large inlets. (Piers are also perpendicular to shore but are built to access ships and boats.) Seawalls are on shore and built parallel to the beach but deflect wave energy into the sand in front of and next to them which cause erosion. Beach sand is sometimes imported to fight erosion. But that sand is often from deeper waters so is fine grained and often erodes faster. Building on solid substrate, like a rocky shore, and a reasonable distance away from the water, is a more sustainable method of coastal construction.

Materials

For each group:

- Photos of sand samples of a beach transect
- Two clean paint roller trays
- Four cups of various-sized sediments (fine sand, coarse sand, small gravel, mixture) for making a beach in the paint tray
- Water
- Small wave makers (3″ x 5″ pieces of wood or plastic)
- Photographs of developed and undeveloped coastlines (e.g., harbors, jetties, breakwaters, groins)
- Small pieces of blocks, wood, popsicle sticks (to resemble structures)
- **Sand Grain Sizes** student sheet
- **Beach in a Pan Investigation** student sheet
- Science notebook

VOCABULARY

Berm: the farthest place sand is deposited by waves on a beach

Groin: a structure perpendicular to and extending from a beach

Profile: a vertical view or cross section of land; may show elevation

Sediment: naturally occurring matter that is deposited by water, wind or glaciers

Transect: a sample area, usually a strip of land along a line, chosen for study

ELL TIPS

Building on prior knowledge is an important support for English Language Learners encountering new concepts. Prior to the activity, read books, show videos or visit a beach to place the activity in the context of the shorelines and their characteristics.

Teacher Preparation

1. If you live near a beach, collect small sand samples at four intervals along a **transect** from the waterline to the edge of the beach. Take close-up photographs of each sand sample site and label with a number or letter (students will use these to sequence grain size). Keep track of the location of each sample in relation to the waterline. Make one set of photos for each student group. (If you don't live near a beach, various-sized sediment can be found at home improvement stores.)

2. Gather the materials for each group to make a sandy beach model. Use different sizes of sand and gravel. Paint trays work well as containers since they already have a slope. (If you do not use a paint tray, you may prop up one end of your pan to form shallow and deep parts.)

THE MISSION OF THE MONTEREY BAY AQUARIUM IS TO INSPIRE CONSERVATION OF THE OCEANS.

Procedure

1. INTRODUCE THE FOCUS QUESTION TO THE CLASS.
   Share the question: *How do waves shape beaches?* You may write it up on the whiteboard or have students add it to their science notebook. Give students time to write their initial thoughts down or discuss with a partner.

2. ENGAGE STUDENTS INTEREST ABOUT BEACHES AND SAND.
   Discuss beaches with students. *Who has visited a beach before? What is a beach made of? Does a beach look the same all year? Why or why not? Are all beaches the same? What moves the sand? (wind and water)*

Part One: Sand Grain Sizes

3. STUDENTS PREDICT THE LOCATION OF SAND SAMPLES FROM A BEACH TRANSECT.
   Where does sand come from? Why are there different sizes of sand on a beach? Pass out a set of the sand sample photographs and/or the samples. Have them predict which order the sand grains are in from the waterline to the backshore of the beach. Challenge them to sequence the photographs in the correct order and record their prediction on the **Sand Grain Sizes** student sheet or in a science notebook. (For younger students, discuss as a class.)

4. STUDENTS BUILD A BEACH IN A PAN AND OBSERVE THE INFLUENCE OF WAVES ON SAND GRAIN SIZES.
   Give student groups a paint roller tray, cup for scooping, wave maker and access to sand and water. Each group will need about four cups of sand to fill up the shallow portion of the paint tray. Encourage students to investigate the different textures, colors and grain sizes of sand before adding water. Next have student groups pour water into their pans until it covers a small section of the sand. Challenge them to make waves of the same size and frequency. *How do the waves affect the sand?* Have students slowly make waves that sweep up onto the sand until at least half of the sand is washed from the sand pile and extends down the slope toward the deep end of the container.

5. REVISIT THE SAND SAMPLES TO MAKE COMPARISONS.
   Look at the original pictures of the beach transect sand samples. Based on their experimentation, do students want to make any changes in the order they placed the photos? Compare their responses to the expected answers and discuss the forces at play on a beach. *How does the size and frequency of waves affect the distribution of sediment? What about wind?*

CONSERVATION TIPS

Coastlines are a popular place for human habitation. Erosion and habitat destruction are the drawback to so much human activity on our shores. When visiting shorelines, decrease your impact by treading lightly and leaving things as they are.

Part Two: Investigate Forces on a Beach

6. STUDENTS INVESTIGATE THE EFFECT OF VARIOUS FORCES ON A BEACH PROFILE.
   Have students reshape their beaches. Challenge them to choose a variable (beach slope, wave size and frequency, angles that the waves hit the beach) with which to experiment. *How do they think each variable affects beach formation?* Pass out **Beach in a Pan Investigation** sheets or have students record their observations in a science notebook. Have students compare their beach profiles. What similarities and differences do they notice?

7. DISCUSS FINDINGS AS A CLASS.
   What did students find out about forces that shape a beach? Discuss some of the similarities and differences between various profiles. *Why were there so many variations? What are factors that affect the formation of different beaches? How do you think beaches change over time or between seasons?* Brainstorm other variables that may occur at a beach (e.g., wind, a river mouth, and so on.). Can students simulate those variables in an investigation?

Part Three: Coastal Development

8. STUDENTS EXAMINE PHOTOGRAPHS OF DEVELOPED AND UNDEVELOPED AREAS.
   Pass out a variety of photographs of coastlines. What do students notice about those that are developed and that have buildings? What do they notice about natural coastlines? *Why would people want to build near a sandy beach area? What coastlines would be the most stable for construction? What are some ways people may combat beach erosion near developed coastlines?*

9. GROUPS SIMULATE THE DEVELOPMENT OF A COASTLINE.
   Challenge students to develop, or build on, their beach in a pan. Pass out popsicle sticks, small blocks of wood and other objects to represent structures. *Where will they place the structures? Why? How can they protect the structures from erosion and waves?* Have students create waves. *What happens? Where are the structures the most stable?*

10. DISCUSS RESULTS AS A CLASS.
    Lead a class discussion with questions such as; *where was the best place to build on their coastlines*? *What sediment size seemed to be the most stable? What strategies did students use to protect their structures from erosion? Which were the most effective? What are pros and cons of people building on coastlines?*

11. RETURN TO THE FOCUS QUESTION.
    Now that students have built a beach in a pan, have them revisit the question: *How do waves shape beaches?* Students may think on their own or discuss with a partner. Then in their science notebook, you may have them draw a line of learning and under it add to their original thoughts about the question.

Extensions

Have a class debate. Recent hurricanes and tsunamis have had devastating effects on coastal communities. What role should the government have in restricting building and paying to rebuild coastal communities?

Resources

Website

Monterey Bay Aquarium www.montereybayaquarium.org

Find images of sandy shores and sandy shore animals.

Books

Marks in the Sand. Woolley, Marilyn. National Geographic, 2001.
One Small Square: Seashore. Silver, Donald M. Learning Triangle Press, 1993.
Shoreline. Taylor, Barbara. Dorling Kindersley, Ltd., 1993.
Science at the Sandy Shore. Jerome, Kate Boehm. National Geographic, 2003.

Standards

Next Generation Science Standards www.nextgenscience.org
Performance Expectations
Relates to 3-ESS3-1: Make a claim about the merit of a design solution that reduces the impacts of a weather related hazard

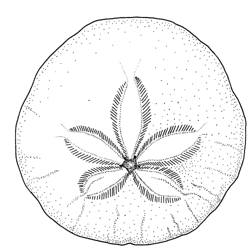
Relates to 4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move

Relates to 5-ESS2-2: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere and/or atmosphere interact

Common Core State Standards www.corestandards.org
Mathematics Practices
MP.5: Use appropriate tools strategically

IN EVERY OUTTHRUST HEADLAND, IN EVERY CURVING BEACH, IN EVERY GRAIN OF SAND THERE IS THE STORY OF THE EARTH.

RACHEL CARSON



Sand Grain Sizes

Name:

Sand is always in motion. Beaches are always changing.
How do waves and wind affect sand grain size on a beach?

PREDICT

- Sequence the sand samples in the boxes below.

Water					Dunes or Parking Lot

- I think the sand grain sizes on a beach are influenced by:

- Explain your thinking.

EXPLORE

Build a beach in a pan.

1. Cover the shallow end of your paint pan with sand grains of different sizes.
2. Slowly pour water into the deep end of the pan.
3. Use your wave maker and practice making waves in the pan. Try to make waves of the same height and frequency.
4. Reshape the sand to what it was when you began making waves. SLOWLY make waves that sweep up onto the sand. Keep making waves until over half of the sand is washed from the sand pile and extends down the slope toward the deep end of the pan.

Answer these questions:

- What caused the sediment to move?

- What caused the sediment to stop moving?

- Change the size and frequency of your waves. How does that affect the distribution of sediments?

- Was your prediction correct? Why or why not?

Name:

Beach in a Pan Investigation

What causes beaches to have different shapes?
Reshape your beach in a pan to the original setup.
Choose one of the variables listed below. Follow the instructions for how to change your beach.
Create waves and record your data below.

QUESTION

- How does ____________________________ affect beach shape?
  (Write in one variable.)

PREDICTION

- I predict the shape of the beach will____________________________________
  (change, stay the same, lose sand, so on)

  because ____.

- Illustrate the profile of your beach.

PROCEDURE

- I changed this variable: ____
  (beach slope, wave angle, wave size or wave frequency)
- I kept these variables the same: ______________________________________
  (amount of water, amount of sand, etc.)
- Now illustrate the profile of your beach.

CONCLUSION

- My prediction was SUPPORTED NOT SUPPORTED because:
  (Circle one.)

Choose one to investigate!

Experimental Variables

Beach Slope (angle)
How do you think the slope of the beach affects its shape? Put a book or block of wood under the sand end of the pan to increase the slope.
Wave Size and/or Frequency
How do large waves affect the shape of the beach? Small waves? Fast waves? Slow waves? Move the wave maker slower or faster and with more and less force to change the waves.
Wave Angle
What happens if the waves come from a right (90 degree) angle? What if they come from an acute angle such as 60 degrees or 45 degrees)? Change the orientation of the wave maker in the water to change the angle of the waves to the beach.