Sifting Sanctuary Sands

Grade Level

6–8 or higher

Timeframe

50 minutes or more

Materials

- Computer, projector and screen
- Printed visual materials (all available to download)
- Text documents (all available to download)

Key Words

Deposition, erosion, rock cycle, sediment, weathering

Standards

NGSS: MS-ESS2-2.
CCSS: W.6.10. SL.6.4.
Ocean Literacy Principles: 1, 2.
Climate Literacy Principles: 7, 3.
Details at end of lesson

A beach at Monterey Bay National Marine Sanctuary: What can sand at marine sanctuaries tell us about the ocean and its interactions with the land?
Photo: Katie Holmes/NOAA

Activity Summary

Students "visit" locations in Hawai'i and on the West Coast by exploring a model of the Pacific basin, analyzing close-up photos of sand at various beaches in national marine sanctuaries and monuments. They create their own system of categorizing sand, explore the visual samples and compare them to actual sand found in your local area (if available). They learn about methods scientists use to classify sand and apply those methods. Students speculate about the origins of sand and geological processes that create it. They realize that many constructive and destructive forces are at work between land and sea.

Learning Objectives

Students will:

- Analyze differences in sand samples and relate that to geologic processes and the biotic communities near beaches.
- Hypothesize about the forces that create sandy beach environments.
- Explain how ocean coastlines relate to the rock cycle.

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&

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Background Information

National marine sanctuaries are a network of underwater areas in the ocean and Great Lakes that protect America's most iconic natural and cultural marine resources. Sanctuaries located on the West Coast and in the Pacific basin possess beautiful and dramatic coastlines, some of which include sandy beaches. Sand within these sanctuaries is dramatically different. Many Hawaiian sands are volcanic in origin and some include coral or other biological remnants. At Olympic Coast National Marine Sanctuary, sediment is composed of different-sized rocks and is metamorphic and sedimentary in origin.

What are the sources of this sand on Kiholo Beach, Hawai'i Island? Photo: Justin Umholtz/NOAA

What are the sources of this sand from Olympic Coast National Marine Sanctuary? Photo: Carey Floyd/NOAA

Sand is an intriguing way to discuss geological processes such as erosion and deposition.

Sand Formation

Sand consists of tiny bits of animals, plants, rocks and minerals. Sand comes from many locations, sources, and environments. It forms when rocks break down from weathering and eroding over thousands and even millions of years. Rocks take time to decompose, especially quartz (silica) and feldspar.

Often starting thousands of miles from the ocean, rocks slowly travel down rivers and streams, constantly breaking down along the way. The sand particles undergo abrasion by being rubbed against other sand and rock particles. Some sand also forms from locally-eroded cliffs or other nearby rock formations. Once particles make it to the ocean, they further erode from the constant action of waves and tides.

Shifting Sands

Sand may travel long distances, carried by wind and waves. When the tide goes out, it takes some sediment with it. Tides and ocean currents can carry sediment a few meters or hundreds of kilometers away. Tides and currents are the main way beaches are created, changed and even destroyed, as the currents move sediment and debris from one place to another.

Categories

Scientists use different methods to describe sediments. They observe size, shape and the probable source of the sand. These "3 Ss" of sand are informative about the beach that it came from. Grain size is measured using the Wentworth scale. Typical grain sizes found on beaches are cobbles, pebbles and sand. The grain size indicates the energy of wave action on a beach. Areas where wave action is strong tend to have larger sediments because more energy allows for the transport of heavier rocks.

Smaller grains tend to be found in areas of calmer wave action and low current speed.

The shape of sand particles is important because it reveals information about their history and origins. Rough, irregular particles are younger than rounded, smooth ones. Rough or sharp-edged particles become rounded and polished through weathering, which includes changes caused by waves, wind and rain. When wind or waves move particles, the particles rub against each other, wearing down rough edges and smoothing surfaces. Sand particles from beaches with lots of wave action are smoother than those from beaches with little wave action.

Composition

Sand particles originate from two main sources: rock (abiogenic) and organic material (biogenic). The tan color of most sand beaches is the result of iron oxide, which tints quartz a light brown, and feldspar, which is brown to tan in its original form. Black sand comes from eroded volcanic material such as basalt rocks (formed from cooled lava) and other dark-colored rocks and minerals, and is typically found on beaches near volcanic activity. Black-sand beaches are common in Hawaii.

The black sands of Kiholo Bay beach, Hawai'i Island Photo: Heather Harvey CC BY-SA 2.0

The by-products and remains of living things also create sandy beaches. As the tide comes in, it deposits ocean sediment. This sediment may contain sand, shells, seaweed and even marine organisms like crabs or sea anemones. Bits of broken-down coral, made of calcium carbonate, are included in some sand in Hawai'i. Some of this sand is even created by parrotfish, which consume coral, grind up the hard parts in their guts and excrete it as smaller particles. Remains of organisms with shells (e.g., clams) or exoskeletons (e.g., urchins) and shells from tiny diatoms and foraminifers also create the organic components of sand. Thus, one may discover which organisms live in an area by examining sand samples.

What marine animals produced these sands on Lalo (French Frigate Shoals), Papahānaumokuākea Marine National Monument? Photo: Justin Umholtz/NOAA

A Home for Tiny Creatures

Sand is also the home of numerous small organisms, called meiofauna, that live in the spaces between the sand grains. Marine meiofauna are typically smaller than 1 millimeter (0.04 inches) and larger than 32 micrometers (32/1000 of a millimeter). These animals are a diverse and very important, yet often overlooked part of marine ecosystems. They can be food sources for small fishes, large worms and crabs that sift through sediments. They themselves feed on many different small

food items such as bacteria, detritus and other microscopic organisms, and can be highly specialized in their diet. Thus, they form an important link in marine food webs.

What creatures are burrowing in the sand at this beach in Olympic Coast National Marine Sanctuary? Photo: Carey Floyd/NOAA

Learn more:

"Beach." National Geographic Society: https://education.nationalgeographic.org/resource/beach/

"Coastal Sediments—Sorting." National Park Service: https://www.nps.gov/articles/coastal-sediments-sorting.htm

"Erosion." National Geographic Society: https://education.nationalgeographic.org/resource/resource-library-erosion

"What are "marine meiofauna"?" NOAA: https://oceanexplorer.noaa.gov/facts/marine-meiofauna.html

Vocabulary	
Abrasion	The physical process of rubbing, scouring or scraping whereby particles of rock are eroded away by friction
Deposition	The process in which sediments, soil and rocks are added to a landform. This can build up layers of sediment.
Erosion	The action of surface processes (such as water flow or wind) that removes soil, rock or dissolved material from one location and then transports it to another location. Erosion is distinct from weathering, which involves no movement.
Rock cycle	The processes that explain the relationship between the three rock types: igneous, sedimentary, and metamorphic. Any rock type can become another type through weathering, melting, cooling and/or compression.
Sediment	Solid material that is moved and deposited in a new location. Sediment can consist of rocks and minerals, as well as the remains of plants and animals.
Weathering	The breakdown of rocks, soils and minerals by either physical or chemical processes. Weathering is an important part of the rock cycle.

Preparation

- Set up an outdoor area or the classroom to represent the Pacific basin, so students can "visit" beach locations in Hawai'i and on the West Coast. See a map of the locations below and on Slide 2 of the "Sifting Sanctuary Sands images for print" PowerPoint.

- Print the images in the "Sifting Sanctuary Sands images for print" PowerPoint on 8.5" X 11" paper. You might choose to protect them with clear sheet protectors or laminate them. Arrange them around the room or outdoor area to represent their relative locations shown on the map above. They could be on desks/tables to represent the Hawaiian Islands and West Coast, or placed on the ground and held down with containers of sand or rocks.
- Download and prepare to show the "Sifting Sanctuary Sands presentation."
- Print copies of the "Sifting Sanctuary Sands handout," one for each student.
- Prepare to play traditional Hawaiian music to create a fun and relaxing beach atmosphere. One option is Kealiʻi (pronounced Kay-ah-LEE-ee) Reichel. "Lei Haliʻa" is one classic song: https://youtu.be/WjLR1NmbF7Q
- *Optional:* Collect about a gallon of sand from a local area, if possible, or purchase a bag of sand. Divide it into 9 smaller containers, such as baking pans, and add one to each of the 9 sand sites. Students can compare local sand to the photos of sand at the various locations, and it can be used to hold the printed photos in place.
- *Optional:* Magnifying devices such as hand lenses and macro lenses, which can be attached to device cameras. These can be used to observe sand samples and photos in more detail.
- *Optional*: Encourage students to bring in sunglasses, flipflops, beach attire or sand castle pails to get excited about the investigation and prepare for their day at the "beach."

Procedure

Engage

- Play traditional Hawaiian music and share this scenario with students:
  Close your eyes and imagine you are on a beach in Hawai'i. What does the beach look like?
  Is it a sandy or rocky beach? What do the sand and/or rocks look like? Today we are going to be "visiting" beach locations around the Pacific basin, including Hawai'i and the West Coast.
    - Ask: Where does the sand on beaches come from?
    - Ask students to share their ideas in a think-pair-share and/or class discussion.
- Show slide 2 of the "Sifting Sanctuary Sands presentation." Ask: What do you see in this photo? What do you notice about the sand? Does this sand look like sand you have seen before? What could be the source or sources of it? Ask students to share their ideas in a think-pair-share and/or class discussion.
- Advance to slide 3 showing different sands. Ask: What system or systems could you use to describe sand samples? What are different ways you could categorize sand? Ask groups to explain their categorization systems in science notebooks in words and pictures and be ready to discuss them as a class.
- After a couple minutes, ask students to share their ideas. Then briefly talk students through the slides that explain how scientists classify grain size and shape of sediment.
- Pass out the handouts, one for each student, and discuss the system of classifying sand shown on the table. Tell students that the scientific system of describing sand according to color, grain size, shape, and source is what they will be using as they "visit" Pacific basin national marine sanctuary locations today.

Explore

- Point out your model of the Pacific basin in the classroom or take the students outdoors to where it is arranged. Explain that the nine sites listed on the handout correspond with the nine locations in Hawai'i and along the West Coast that have been arranged.
- Divide the class into 9 heterogeneous groups of 2–4 students each. Assign each a number that corresponds with the site numbers. Tell students that they will have 5 minutes at their first site to record their observations of the sand on the handouts or in science notebooks in words and pictures.
- Ask the students to "travel" to their site and discuss their ideas about the sand there, recording observations on their handouts or in science notebooks. They should also think about how the sand may have formed and compare them to sand found in your local area (if available). Circulate through the groups, answering and asking questions to help them get started.

    - Ask students to classify the sand at their station using the tables on page 2 of the handout and answer the questions.
    - After 4 minutes, give students a 1-minute warning that they should finish recording their ideas and prepare to "travel" to the next site.
- Ask students to rotate between stations and continue filling out the table and answering the questions. Give them 4–5 minutes at each additional station and ask them to be ready to share their ideas with the class.

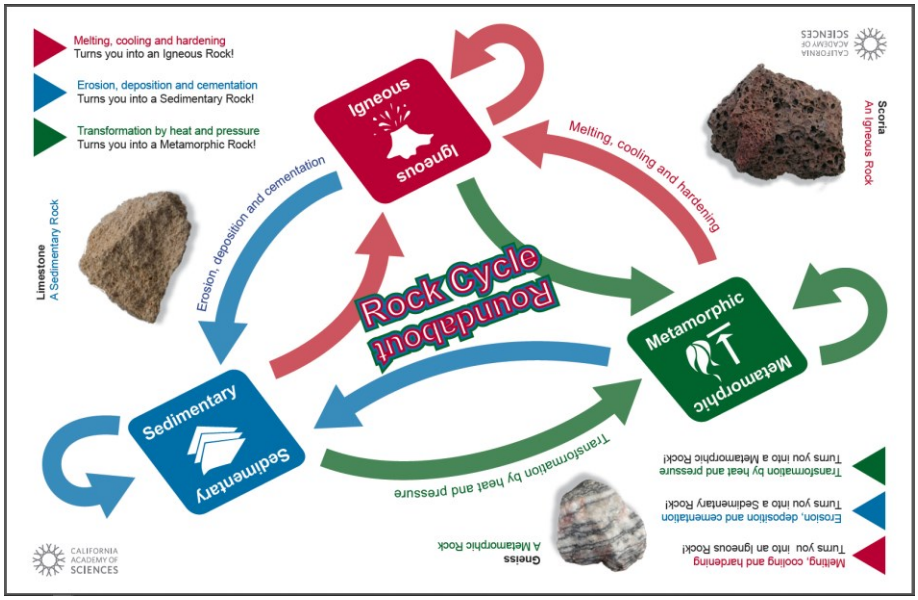
Explain

- Use the interactive "Explain" section of the presentation to facilitate an enjoyable class discussion about the sand samples and sites. See the Slide Notes for additional information.
- Ask students to share their ideas about sand formation and sources. Discuss how most of the rocks in Hawai'i are volcanic in origin, which helps to explain why many of the sands are black. Ask: Why are Hawaiian sands also white? Discuss the role of marine animals in creating sands from their bodies, many of which are made of calcium carbonate.
- Ask students: Do you think anything lives in sand? What are those organisms?
    - Ask them to research some of the animals including meiofauna, sand dollars (an echinoderm) and many species of annelids (worms) that make their homes in sandy environments. Important plants, such as eelgrass, which traps sediment and stabilizes the substrate, can also be researched.
- Ask students: Is sand only found on beaches, or where else is it found?
    - Students may share that it is also found in deserts. Be sure that they understand that sand and sediment are also found across vast swaths of our global ocean, which covers about 70% of Earth's surface.
    - This huge area of the ocean floor provides important habitat, including in our national marine sanctuaries. Cordell Bank National Marine Sanctuary is one that lies entirely offshore—no beaches, but lots of sand and sediment for marine life!
- Ask students to share their ideas about the rock cycle. Use the rock cycle slides in the presentation to clarify ideas and increase understanding. Explain erosion and deposition of sand and the sources of these sand samples with the support of the visuals.

Enrich/Extend

- Take the students on a field study to observe sand, interesting rocks and landforms first-hand. Observations can be recorded in field journals in words and illustrations. Good locations to take your class include beaches along rivers, creeks and lakes if you live far from the ocean.

- Play the “Rock Cycle Roundabout” game from the California Academy of Sciences. Lesson plan and materials: calacademy.org/educators/lesson-plans/rock-cycle-roundabout



- Students can create new games that help others explore different types of rocks and sand and how they are created. Encourage students to create engaging game boards, cards, interactive computer games and/or other resources to make the games more fun and educational.
- Ask students to do short research projects about a type of rock, mineral or sand of their choice. They can present to the rest of the class about it, how it was created and why it is interesting and/or important.
- Ask students to think about how the beaches they explored might be impacted by various effects of climate change. They can discuss these with a partner or small group and record their ideas in words and illustrations. Ask the students to share their best ideas with the class, which may include increased erosion of the beaches from sea level rise and more intense rainstorms, more destructive storm surges from tropical storms, degradation of habitat for sea birds, sea turtles and marine mammals that depend on beaches to reproduce. You might also discuss how increasing carbon dioxide levels in the atmosphere are causing ocean water to become more acidic, threatening the survival of shell-building marine species and the entire food web of which they are a part. This also impacts beaches that are built in part by calcium carbonate shells of marine animals.

  Encourage students to think of solutions to mitigate the destructive impacts of climate change. They can share them with the school and larger community through a medium of their choice, such as posters, public service announcement videos and/or audio recordings, games or skits.

Evaluate

- Ask students to explain how ocean coastlines relate to the rock cycle, orally and/or in writing. They can create a model of the rock cycle in a format of their choice to help explain the concepts. They can create a labeled diagram like the one in the PowerPoint presentation, a short video, a diorama or another format.
- Ask students to construct an explanation based on evidence for how geoscience processes have changed Earth's surface (MS-ESS2-2). They should record their ideas in science notebooks and/or share them orally.
- Review student answers to the questions on the handout. Review additional work products and science notebooks.

Education Standards	
Next Generation Science Standards	Ecosystems: Interactions, Energy, and Dynamics • MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.] Science and Engineering Practices: • Engaging in Argument from Evidence Crosscutting Concepts: • Cause and Effect • Systems and System Models
Common Core State Standards	Writing: W.6.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. Speaking and Listening: SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes.
Ocean Literacy Principles	1. The Earth has one big ocean with many features. (g) 2. The ocean and life in the ocean shape the features of Earth. (c)
Climate Literacy Principles	7. Climate change will have consequences for the Earth system and human lives. (a, b, c) 3. Life on Earth depends on, is shaped by, and affects climate. (a, c) (If the last Enrich/Extend activity is completed.)

Additional Resources

"Coastal Erosion: Where's the Beach?" NOAA Sea Grant: https://masweb.vims.edu/bridge/datatip.cfm?Bridge_Location=archive0500.html

"The Rock Cycle." National Geographic Society: https://education.nationalgeographic.org/resource/rock-cycle

"Sand Lab." Adapted from *The Fluid Earth / Living Ocean*. University of Hawai'i: https://www.hawaii.edu/gk-12/evolution/pdfs/meiofauna.sand.lab.highschool.pdf

"Sediment Sorting" lesson. National Park Service: https://www.nps.gov/teachers/classrooms/sediment-sorting.htm

This lesson was inspired by a "Sand Exploration" activity created by the Georgia Association of Marine Education: https://gaome.wildapricot.org/page-18087.

For More Information

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