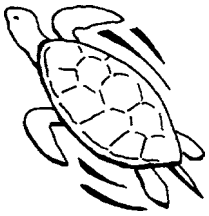


Activity #1

Sand Analysis Lab

● ● ● Class Period One *Sand Analysis Lab*

Materials & Setup

- "Oneuli and Oneloa Beach" acetates (master, pp. 12-13)
- Overhead projector and screen
- Map of Maui

For each lab group of three to four students

- Student Page "Sand Analysis Lab Procedures and Resources" (pp. 14-17)
- Student Page "Sand Analysis Lab Data Sheet" (pp. 18-20)
- Two 1/4-cup samples of sand, one each from Oneuli and Oneloa beaches (included with this curriculum; instructions for collecting more in "Guidelines for Collecting Sand," p. 8)
- Four sheets of notebook paper or white paper
- Millimeter ruler (ideally with fractions of millimeters marked)
- Teaspoon
- Two petri dishes or small bowls
- Two tbsp. vinegar
- Two hand magnifying lenses or dissecting microscopes (higher magnification is better)
- Forceps capable of picking up one grain of sand
- Two weighing papers or small squares of construction paper
- Magnet
- Glue and a few toothpicks OR cellophane tape

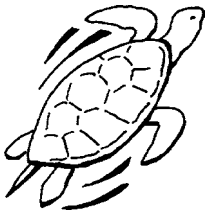
For each student

- Student Page "Questions Following the Sand Lab" (pp. 21-22)

Instructions

1) Before beginning the lab, ask students to think of their favorite beaches on Maui. What makes these beaches stand out from the others?

2) Have each student identify a familiar beach and write a description of the sand at that beach. Challenge students to make that description as detailed as possible. (If students are keeping a journal, have them write these descriptions as entries.) If students are having difficulty, ask them questions such as:
   - What does it feel like when you walk or sit on it? Is it smooth, sharp, gritty?
   - What color or colors is it?
   - Is the sand uniform size, or are there larger pieces of rock, coral, or shells mixed in with smaller sand grains?
   - Does it stick to your body or is it easy to brush off?
   - Are the grains coarse or fine? How do they compare with other beaches?



3) Ask several students to share their descriptions until you have heard some clear contrasts. Then have the class draw comparisons among the sandy beaches described. Ask students to brainstorm about what might cause these kinds of differences in sands at different beaches. Write their ideas on the board or overhead.

4) Have students brainstorm what sand is made of and record those ideas as well. (There are two basic components of sand: "Biogenic" components are the fragmented or whole remains of marine animals and plants that have hard skeletons of calcium carbonate. These organisms include corals, molluscs, sea urchins, single-celled animals called "foriminifera," and algae. "Detrital" components are fragments of rock that have been worn down through weathering and erosion. They include eroded basalt, the most common material in lava flows; sharp fragments of lava called volcanic glass; and minerals such as garnet, olivine, and magnetite.)

5) Have students brainstorm what could cause differences in grain size (how coarse or fine the sand is) at different beaches. (Particle size is influenced by the materials from which the sand is made and how easily they are broken and worn down. Another key factor in determining particle size is wave size and energy. Each crash of a wave on shore temporarily suspends some sediment—sand—in water. The amount of sediment is directly proportional to the size of the wave. The size of the sediment that can be transported by a wave is also proportional to its size and energy. A beach subject to large crashing waves will generally have coarser sand than one that is lapped by small calm swells because the larger waves can transport the finer sediments out to sea. This factor can account for seasonal differences in the sand size at beaches, as well.)

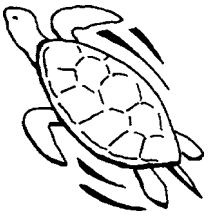
6) Display the acetates of Oneuli and Oneloa beaches. Locate the beaches on the map of Maui (they are just north and south of Puʻu Ōlaʻi, near Mākena). Find out if any students have been to these beaches. They may know the beaches by other names. Oneuli is sometimes called "Black Sand Beach." Oneloa is also known as "Big Beach." Tell students they will be studying these two beaches more during this activity.

7) Divide the class into lab groups of three to four students. Make sure they have all of the equipment they need and hand out the Student Pages "Sand Analysis Lab Procedures and Resources" and "Sand Analysis Lab Data Sheet."

8) Pass out labeled sand samples from Oneuli and Oneloa beaches. Ask students to look at the beach photos (leave the acetate images up) and the sand samples. Ask them to generate hypotheses about the composition and relative grain size of the sand at each beach, and record these hypotheses on their group's lab sheet.

9) Run the sand analysis lab, following the instructions on the Student Page "Sand Analysis Lab Procedures and Resources."

10) As homework, assign the Student Page "Questions Following the Sand Lab."

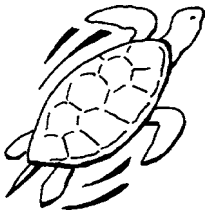


Journal Ideas

- Go to a beach and write down everything you can observe about the sand. Think about why it might be the size and composition that it is, and write your ideas.
- Write a chant or a poem about the sand on Oneuli or Oneloa beach.

Assessment Tools

- Participation in class discussion
- Lab conduct
- Student Page "Sand Analysis Lab Data Sheet"
- Student Page "Questions Following the Sand Lab" (teacher version, pp. 10-11)



Teacher Background

Guidelines for Collecting Sand

Sand samples are provided for the lab in this activity. These guidelines are intended for enrichment activities or if you need to replenish the samples that came with this curriculum.

1) Collect small samples, about 1/4 cupful of sand for each lab group.

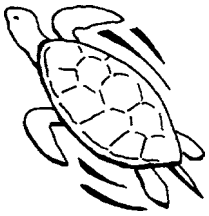
2) If you are taking samples from more than one beach, collect the samples in approximately the same location at each beach (e.g. near the water line, middle beach, or near the back of the beach). This will make your samples more comparable.

2) Place each sample in a clean plastic bag or covered container. Seal the container and label it with the following information:
   - The name of the beach
   - The date of collection
   - The location on the beach (e.g., swash zone, middle beach, near the back of the beach)

3) Take the sand samples home, rinse each one in fresh water, and spread them out to dry on newspapers or paper towels in a sunny, protected spot. When they're completely dry, put them back in their dry containers.

Conservation Note

Even though it may seem as though you're taking a very small amount of sand from the beach, please be careful to take only as much sand as you need. Unless you are saving it for future classes, please return the sand after you are finished using it. Think about what would happen to our beaches if many people were removing sand from them.



Teacher Background

General Outcomes for the Sand Analysis Lab

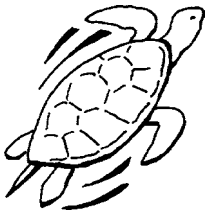
Although specific lab results will vary, student observations will probably be similar to those given below.

Oneloa Beach

- Smaller grain size—averaging around .5 mm (.02 inch)
- Golden color with some white and black flecks
- Higher percentage of biogenic components
- A few magnetic grains present

Oneuli Beach

- Larger grain size—averaging between .5 and 1 mm (.02 and .04 inch)
- Brown-black color with red, white, and orange flecks
- Lower percentage of biogenic components
- Many magnetic grains present



Teacher Version

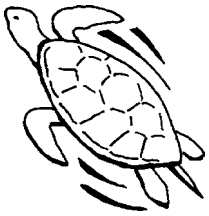
Questions Following the Sand Lab

1) Based on the differences in sand grain size between Oneloa and Oneuli beaches, develop a hypothesis about the environmental conditions at both beaches.

Well-reasoned responses are acceptable. The finer sands at Oneloa suggest smaller, less energetic waves overall than at Oneuli, where the sediments are larger.

2) What could explain a seasonal variation in sand grain size on many sandy beaches?

Well-reasoned responses are acceptable. Stormier weather during the winter tends to bring larger waves, increasing sand grain size on beaches. As gentler summer swells again predominate, sand grain size decreases again. The seasonal effects differ from beach to beach, depending upon how exposed they are to winter storm waves.



3) Scientists who study sand and coastal areas have observed that the average size of particles on a beach is correlated to the slope of the beach. In general, the steeper a beach is, the larger the particle size.

   The table below shows part of the Wentworth scale, a system of classifying sediments by particle size. Look at the table and think about how you would set up a study to test whether these relationships are accurately described. Write a description of this study.

Type of sediment	**Diameter (mm)**	**Average beach slope**
Cobble	65-265	19°-25°
Pebble	4-64	13°-19°
Granule	2-4	11°
Very coarse sand	1-2	9°
Coarse sand	0.5-1	7°
Medium sand	0.25-0.5	5°
Fine sand	0.07-0.25	5°

Wentworth grain size scale adapted from E. Barbara Klemm, et al., The Fluid Earth: Physical Science and Technology of the Marine Environment, *Curriculum Research and Development Group, University of Hawai'i, Honolulu, 1990, p. 139.*

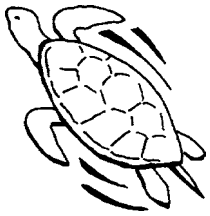
Well-reasoned study designs are acceptable. The essential components to study would be slope and sediment size, across a range of slopes and sediment types.

Oneuli Beach

Photos: Ann Fielding

Oneloa Beach

Photos: Ann Fielding



Sand Analysis Lab Procedures & Resources

Materials

- Student Page "Sand Analysis Lab Data Sheet" (pp. 18-20)
- Two 1/4 cup samples of sand, one each from Oneuli and Oneloa beaches
- Two sheets of notebook paper or white paper
- Millimeter ruler (ideally with fractions of millimeters marked)
- Teaspoon
- Two petri dishes or small bowls
- Two tbsp. vinegar
- Two hand magnifying lenses or dissecting microscopes (higher magnification is better)
- Forceps capable of picking up one grain of sand
- Two weighing papers or small squares of construction paper
- Magnet
- Glue and a few toothpicks OR cellophane tape

Sand-Size Lab Procedure

1) Make a sand-size grid by drawing four squares of different sizes on a piece of notebook or white paper. The squares should measure: 1.5 mm, 1 mm, .5 mm, .1 mm.

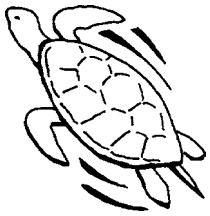
2) Spread out a small amount of sand from the first sample on a piece of notebook paper, making a single layer of sand rather than a pile. Use the forceps to select 25 grains of sand from the sample, and measure each using your sand-size grid. Record your measurements on the data sheet. Calculate the percentage of grains that fall into each size range given on the lab data sheet.

3) Repeat this procedure for the second sample.

4) Now, observe the color of each sand sample, recording your observations on the data sheet. Record how the samples compare to each other in color.

5) Record your group's hypothesis about which sample contains the most "biogenic" sand components, based on comparing the color of the samples. Explain your reasoning. Biogenic sands are made up of the remains of once-living organisms such as shellfish, coral, coralline algae, and sea urchins.

6) Using the hand lens or dissecting scope, observe each sample for remains of plants and animals. Use a forceps to pick up individual sand grains for closer inspection. See the lab resource sheets for images of some of the biogenic sand components you might see. Estimate the percentage of biogenic sand in each sample based on your observations.



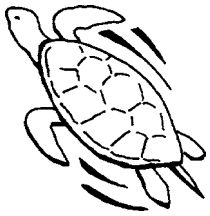
7) Place 1/4-1/2 teaspoon of sand from each sample into a clean, dry petri dish (or bowl). Label each dish with the corresponding beach name. Spread the sand out into an even layer in the bottom of the dish. Pour one tablespoon of vinegar into each dish.

   Vinegar and calcium carbonate, the major component of the shells and skeletons that make up biogenic sand particles, react chemically when exposed to each other. The bubbling you will see is the evidence of that reaction. Observe both samples and note whether one of them bubbles more than the other. Record your observations and note which samples seem to contain the most biogenic components.

8) Using the hand lens or dissecting scope, look for particles of rocks or minerals in each sand sample. These are "detrital" sand components, meaning they are produced by disintegration or erosion. These components are also referred to as "terrigenous" (originating from land) or "abiogenic" (of a non-living origin). Use the reference sheets provided to help you identify different components. Place samples of your findings on the data sheet with tape or glue.

9) Place a small amount of each sand sample on a weighing paper (or square of constuction paper). Hold a magnet under the weighing paper and look for particles of sand that are attracted to the magnet. If you find any of these, they are probably magnetite, a mineral that is an oxide of iron. Note their presence on the data sheet.

10) After you have finished identifying sand components, answer the questions that follow the data tables.



Lab Resource Sheets

Common Biogenic Sand Components

Some animals (such as corals and molluscs) and plants (including some algae and coralline algae) that live on reefs and in shallow marine waters make hard skeletons of calcium carbonate. Fragments of their skeletal remains form much of the sand found on Hawaiian beaches.

Corals and coralline algae build the framework of reefs, which are then broken down into sand by "bioerosion" and "mechanical erosion." Bio-erosion refers to the actions of animals that break down the reef, such as grazing fish and urchins, boring sponges and worms, and bivalves that attach themselves to the reef. Mechanical erosion refers to the forces of wave action.

Some living organisms, such as molluscs, "echinoderms" (a phylum of marine animals including starfish, brittlestars, sea urchins, and sea cucumbers), and other plants and animals that form "calcareous" (calcium-based) skeletons, contribute to sand production directly as their remains are broken and polished by wave action and washed up on beaches.

Fragments of coralline algae

These marine algae secrete large quantities of calcium carbonate to form a robust skeleton. Although they are reddish while they are alive, the skeletal fragments are orange, tan, gray, or whitish.

Coral fragments

Countless individual polyps secrete calcium carbonate to form the reefs in which they live. This reef structure is broken down into pieces and grains of various sizes primarily by the action of waves and marine animals. These fragments are white to gray in color and feel gritty.

Calcareous algae

Halimeda is a genus of green algae that secrete small amounts of calcium carbonate to form a delicate skeleton. The fragments of these skeletons are a whitish color.

Molluscs

Marine organisms such as cowries secrete protective shells of calcium carbonate.

Foriminifera

These tiny "shells" are actually skeletons of single-celled animals, "foriminifera." They are usually tan to yellow in color, and generally round, smooth, and shiny.

Echinoderm spines

Fragments of sea urchin skeletons (or "tests") and spines are common sand components. They range in color from reddish to greenish, brown, or gray. They may be ornamented with beadlike dots.

Images: Jodi Harney

Common Detrital Sand Components

Other sand components are formed as volcanic land wears down through the weathering and erosive forces of running water, plants, temperature changes, chemical reactions, and wave and wind action. These components are referred to as abiogenic, terrigenous, or detrital grains.

Basalt

This is the primary component of lava flows. Eroded basalt forms dull black, gray, or brownish red grains of sand.

Garnet

These crystals are usually amber-colored but may range to a light pink color. Perfect crystals, which have 12 faces, are rare because wave action rounds off the edges quickly.

Olivine

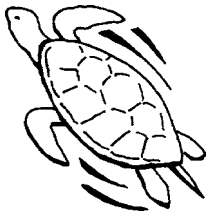
This is shiny, transparent or translucent crystal sometimes found in basalt. It varies from olive green to brownish, and may contain specks of other crystals.

Magnetite

This is a common magnetic mineral with opaque black crystals resembling double pyramids.

Volcanic glass

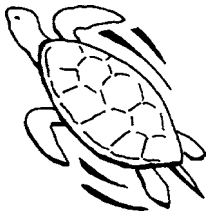
These shiny, black, irregular particles have sharp edges and are formed as hot lava cooled rapidly, often from contact with water.



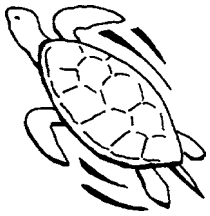
Sand Analysis Lab Data Sheet

Record your hypothesis here:

	Oneloa Beach		Oneuli Beach	
Sand grain size	# of grains > 1.5mm	% >1.5mm	# of grains > 1.5mm	% >1.5mm
	# of grains 1-1.5 mm	% 1-1.5 mm	# of grains 1-1.5 mm	% 1-1.5 mm
	# of grains .5-1 mm	% .5-1 mm	# of grains .5-1 mm	% .5-1 mm
	# of grains .1-.5 mm	% .1-.5 mm	# of grains .1-.5 mm	% .1-.5 mm
Sand size description	Circle the description that best fits: Coarse=>2mm Medium=1-2mm Fine=<1mm Mixed=grains range from coarse to fine		Circle the description that best fits: Coarse=>2mm Medium=1-2mm Fine=<1mm Mixed=grains range from coarse to fine	
Sample color				
Comparison of sample colors				



	Oneloa Beach	Oneuli Beach
Based on color, which sample contains the greatest proportion of biogenic components? Explain.		
Based on the vinegar test and color, estimate the percentage of biogenic components. Explain.		
Detrital components Tape or glue and label an example of each one you find: • Basalt • Garnet • Olivine • Magnetite • Volcanic glass		
Magnetic metals present? Estimate percentage of sample that is magnetic.		



1) Write a one-paragraph description of each sand sample you analyzed. Include information about location, particle size, color, and composition.

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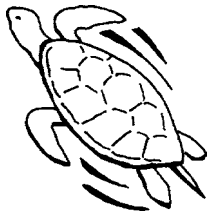
2) Compare the two samples you analyzed.

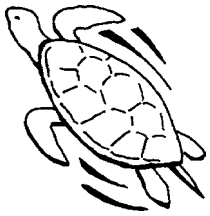
3) Based on your analysis, was your hypothesis correct? Explain.



Questions Following the Sand Lab

1) Based on the differences in sand grain size between Oneloa and Oneuli beaches, develop a hypothesis about the environmental conditions at both beaches.

2) What could explain a seasonal variation in sand grain size on many sandy beaches?



3) Scientists who study sand and coastal areas have observed that the average size of particles on a beach is correlated to the slope of the beach. In general, the steeper a beach is, the larger the particle size.

   The table below shows part of the Wentworth scale, a system of classifying sediments by particle size. Look at the table and think about how you would set up a study to test whether these relationships are accurately described. Write a description of this study.

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