Coastal Unit 1

Beach Today, Gone Tomorrow?

Overview

On Maui, coastal areas have been the focal point of human use since people first arrived here. The coastal ecosystem is the most altered of all native ecosystems on the island, in part due to the physical changes that people have brought to the coastal environment. This unit engages students in understanding the natural processes that shape the shorelines, as well as the effects of human use and development.

Length of Entire Unit

Three class periods

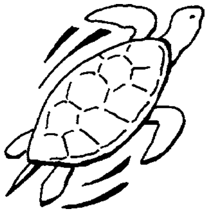
Unit Focus Questions

1) What factors account for differences in sand composition between beaches?

2) How are dunes, beaches, and reefs related in the process of maintaining beaches?

3) What factors cause shorelines to change over time?

4) What are the implications of shoreline changes over time for human activity in coastal areas?



Unit at a Glance

Activity #1

Sand Analysis Lab

Students analyze sand from two Haleakalā beaches to determine differences in composition and grain size.

Length
One class period, followed by homework

Prerequisite Activity
None

Objectives
- Analyze sand samples to distinguish among different types of sand found on island beaches.

DOE Grades 9-12 Science Standards and Benchmarks
DOING SCIENTIFIC INQUIRY: Students demonstrate the skills necessary to engage in scientific inquiry.
- Develop and clarify questions and hypotheses that guide scientific investigations.
- Organize, analyze, validate, and display data/ information in ways appropriate to scientific investigations, using technology and mathematics. *(Students analyze data, for partial fulfillment of this benchmark.)*
- Formulate scientific explanations and conclusions and models using logic and evidence.

Activity #2

Where Does the Sand Come From?

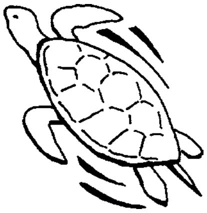
Students use maps and other information to generate hypotheses that explain the differences in sand composition of the two beaches studied in Activity #1.

Length
One class period

Prerequisite Activity
Activity #1 “Sand Analysis Lab”

Objectives
- Generate hypotheses that explain the composition of different sandy beaches.

DOE Grades 9-12 Science Standards and Benchmarks
DOING SCIENTIFIC INQUIRY: Students demonstrate the skills necessary to engage in scientific inquiry.
- Develop and clarify questions and hypotheses that guide scientific investigations.
- Organize, analyze, validate, and display data/ information in ways appropriate to scientific investigations, using technology and mathematics.
- Formulate scientific explanations and conclusions and models using logic and evidence.
- Communicate and defend scientific explanations and conclusions.



Activity #3

Causes and Consequences of Coastal Erosion

Students project coastal erosion along two sandy beaches and identify potentially hazardous areas for development.

Length
One class period (may extend into a second period for some classes)

Prerequisite Activity
None

Objectives

- Explain key elements and relationships in the natural processes that shape coastal areas, including the relationships among dunes, beaches, and reefs.
- Illustrate shoreline changes over time and project future changes.
- Explain how this type of projection could be useful in coastal management.

DOE Grades 9-12 Science Standards and Benchmarks
USING UNIFYING CONCEPTS AND THEMES: Students use concepts and themes such as system, change, scale, and model to help them understand and explain the natural world.

- SYSTEM: Explain the function of a given system and its relationship to other systems in the natural world.
- CHANGE: Explain the effect of large and small disturbances on systems in the natural world.

Enrichment Ideas

- In Activity #1 “Sand Analysis Lab,” use graduated geology sieves to obtain a more accurate measurement of sand grain sizes. If your school does not have a set of graduated geology sieves, make your own set of substitute strainers of different sizes. To construct sieves, use window screening with different mesh sizes mounted on simple wooden frames or on the bottoms of plastic containers such as those that margarine comes in. Measure and mark the grid size of each sieve, and you’re set!
- In Activity #1 “Sand Analysis Lab,” weigh out a small portion of sand (1/4 tsp.) and separate biotic and abiotic particles. Weigh each portion and record percentage composition.
- For a more detailed sand analysis lab, see E. Barbara Klemm, et al., *The Fluid Earth: Physical Science and Technology of the Marine Environment,* Curriculum Research and Development Group, University of Hawaiʻi, Honolulu, 1990, pp. 139-157.
- Analyze sand from other beaches around the island. Use the maps and information included in this unit, along with additional research to hypothesize about the origin of the sand on each beach. Sand collection guidelines are included in the teacher background, Activity #1 “Sand Analysis Lab” (p. 8).
- Compare sand samples taken from the same beach. Take one sample close to the back of the beach and one from the swash zone where water washes up onto the lower beach. There should be a difference in particle size from front to back, demonstrating differences in wave action on different parts of the beach.

- Visit one of the “coastal erosion hotspots or watchspots” identified in the *Beach Management Plan for Maui* at <www.soest.hawaii.edu/SEAGRANT/bmpm/introduction.html>. Observe the shoreline, looking for signs of erosion, structures that have been put in place to slow erosion, alterations that have been made to dunes, and buildings or other structures that look like they may be threatened by coastal erosion. Illustrate written reports with photos or sketches of the area.

- Research the pros and cons of different techniques for beach preservation. The Maui Beach Management Plan (see Whang and Fletcher in “Resources for Further Reading and Research” section) is a good place to start, as well as Internet research using some of the terms used in the Activity #3 “Causes and Consequences of Coastal Erosion” readings.

Resources for Further Reading and Research

Clark, J. R. K., *The Beaches of Maui County*, University of Hawaiʻi Press, Honolulu, 1980.

Davis, Richard A. Jr., *The Evolving Coast*, Scientific American Library, New York, 1997.

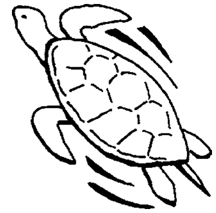
Fletcher, C. H., R. A. Mullane, and B. M. Richmond, “Beach Loss Along Armoured Shorelines on Oahu, Hawaiian Islands,” *Journal of Coastal Research*, Vol. 13, No. 1, 1998, pp. 209-215.

Hawaiʻi Department of Land and Natural Resources, Coastal Lands Program, “Coastal Erosion and Beach Loss in Hawaiʻi” at <www.soest.hawaii.edu/SEAGRANT/CEaBLiH.html>.

Macdonald, Gordon A., Agatin T. Abbott, and Frank L. Peterson, *Volcanoes in the Sea: The Geology of Hawaiʻi*, University of Hawaiʻi Press, Honolulu, 1983.

(Chapter 8 provides detailed background about forces that weather rock and lead to soil formation.)

Whang, Dennis, and Charles Fletcher, Hawaiʻi Office of State Planning, Coastal Zone Management Program, “Beach Management Plan with Beach Management Districts” at <www.soest.hawaii.edu/SEAGRANT/bmpm/introduction.html>.



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

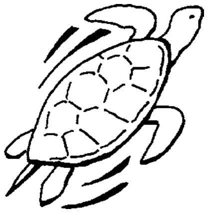
For each student

- 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.)

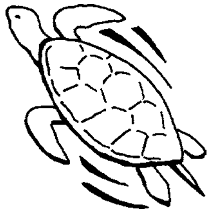
6) Display the acetates of Oneuli and Oneloa beaches. Locate the beaches on the map of Maui (they are just north and south of Pu‘u Ōla‘i, near Mākena). Find out if any students have been to these beaches. They may know the beaches by other names. Oneuli is sometimes called "Black Sand Beach." Oneloa 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."

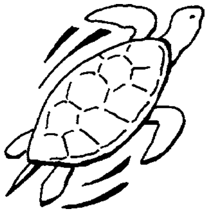


Journal Ideas

- 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.

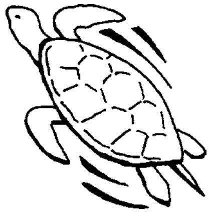
2) If you are taking samples from more than one beach, collect the samples in approximately the same location at each beach (e.g. near the water line, middle beach, or near the back of the beach). This will make your samples more comparable.

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

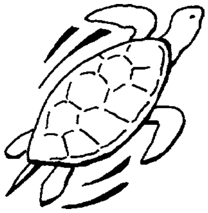
Although specific lab results will vary, student observations will probably be similar to those given below.

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

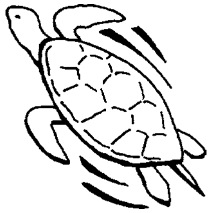
Questions Following the Sand Lab

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.*

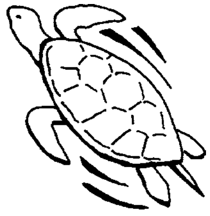
Well-reasoned study designs are acceptable. The essential components to study would be slope and sediment size, across a range of slopes and sediment types.

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.

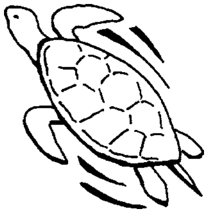
2) Spread out a small amount of sand from the first sample on a piece of notebook paper, making a single layer of sand rather than a pile. Use the forceps to select 25 grains of sand from the sample, and measure each using your sand-size grid. Record your measurements on the data sheet. Calculate the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

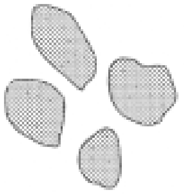
Some animals (such as corals and molluscs) and plants (including some algae and coralline algae) that live on reefs and in shallow marine waters make hard skeletons of calcium carbonate. Fragments of their skeletal remains form much of the sand found on Hawaiian beaches.

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.

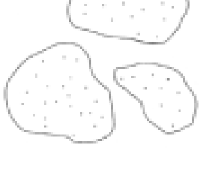


Coral fragments

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.

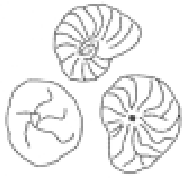


Molluscs

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

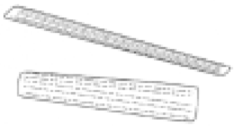
Foriminifera

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

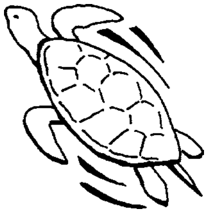
This is shiny, transparent or translucent crystal sometimes found in basalt. It varies from olive green to brownish, and may contain specks of other crystals.

Magnetite

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

Volcanic glass

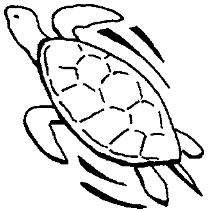
These shiny, black, irregular particles have sharp edges and are formed as hot lava cooled rapidly, often from contact with water.



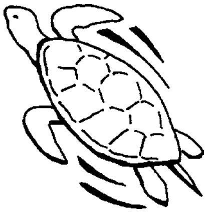
Sand Analysis Lab Data Sheet

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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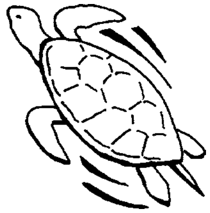
2) Compare the two samples you analyzed.

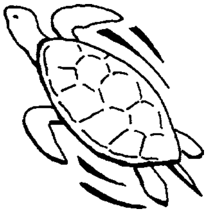
3) Based on your analysis, was your hypothesis correct? Explain.



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?

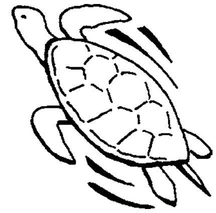


3) Scientists who study sand and coastal areas have observed that the average size of particles on a beach is correlated to the slope of the beach. In general, the steeper a beach is, the larger the particle size.

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.

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.*



Activity #2

Where Does the Sand Come From?

● ● ● In Advance *Setting Up Information Stations*

- Set up four information stations around the room using the "Information Station Graphics" (master, pp. 25-30) for three of them and vials of sand from Oneuli and Oneloa beaches for the fourth. (See class period one materials & setup below.)

● ● ● Class Period One *Where Does the Sand Come From?*

Materials & Setup

- Small, labeled vials containing sand samples from Oneuli and Oneloa beaches (samples included with Activity #1, or instructions for collecting more in "Guidelines for Collecting Sand," p. 8)
- "Information Station Graphics" (master, pp. 25-30)

For each student

- Student Page "Where Does the Sand Come From?" (pp. 31-32)

Instructions

1) Hand out a copy of the Student Page "Where Does the Sand Come From?" to each student.

2) Have students visit the stations, transferring relevant information to their own maps, and answering the questions on the student page.

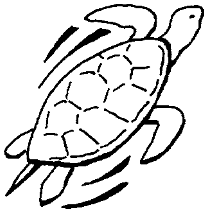
3) Near the end of class, discuss students' hypotheses about where the sand that comprises Oneuli and Oneloa beaches originates, and what accounts for the differences in particle size and composition that they observed during Activity #1 "Sand Analysis Lab."

Journal Ideas

- Find out the meaning of the Hawaiian names, Oneuli and Oneloa. Write a chant or poem, or draw a picture that illustrates where the sand from each of these beaches seems to originate and how it might be deposited on the beach.

Assessment Tools

- Student Page "Where Does the Sand Come From?" (teacher version, p. 24)
- Journal entries



Teacher Version

Where Does the Sand Come From?

Note: You may evaluate student maps, sketches, and notes if desired, looking for thoroughness and accuracy in transferring information from the information stations. In answer to the questions below, look for well-reasoned responses in addition to, or instead of, the suggested answers listed.

1) Where does the sand on Oneuli beach come from?

The dark sand on Oneuli beach is primarily from the basalt wall and cinder slopes. Material from these formations erodes into the ocean (and is eroded by ocean waves) and is deposited by the current on Oneuli beach. (The aerial photo shows an eroded cinder area just up-current from Oneuli beach.) The photos of Oneuli beach show deposits of coral rubble (larger chunks of the reef) among the dark sand. These come from the live coral formation offshore.

2) Where does the sand on Oneloa beach come from?

The light sand on Oneloa beach is primarily from the living coral reef up-current of the beach and dead coral reef offshore. Over time, these biogenic sands have accumulated into offshore sand deposits that also provide sand to the beach.

3) What factors may explain the differences in sand composition and particle size between the two beaches?

The differences in sand composition may be explained primarily by the prevailing ocean currents and the different sand sources available to the two beaches.

Differences in particle size may be explained primarily by the relative hardness of the source materials. The basalt that forms the bulk of the sand on Oneuli is more difficult to wear down than the coral reef and other living sources that provide most of the sand on Oneloa. Another factor affecting particle size may be wave energy. One may anticipate waves of higher energy at Oneuli where average particle size is higher.

4) What additional information would you need to have to be more confident in your hypotheses? How could you collect that information?

Well-reasoned responses are acceptable.

Information Station Graphics

Station #1: Aerial Photos of Oneuli and Oneloa Beaches

Oneuli Beach

Photo: Air Survey Hawai'i

Oneloa Beach

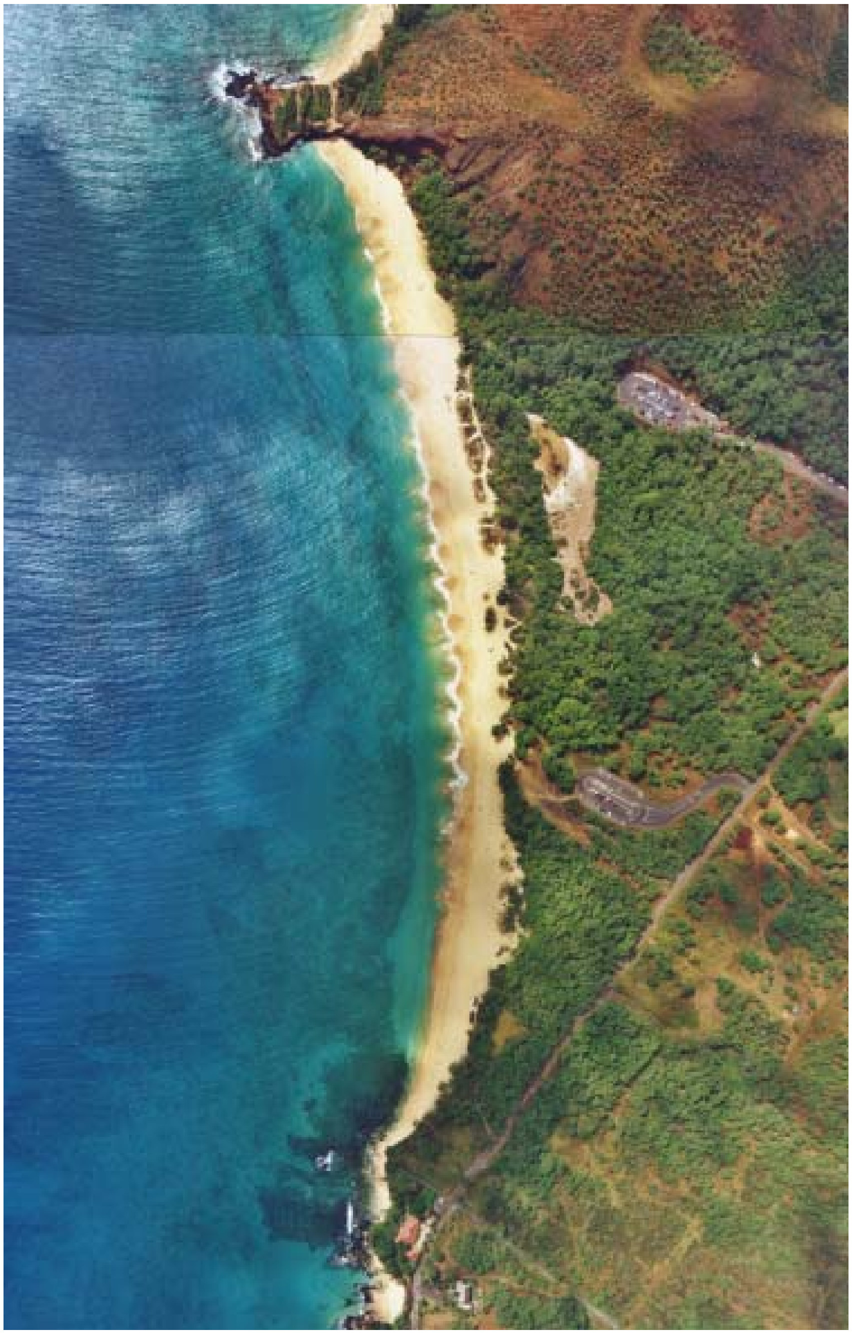


Photo: Air Survey Hawai'i

Station #2: Photos of Oneuli and Oneloa Beaches

Oneuli Beach

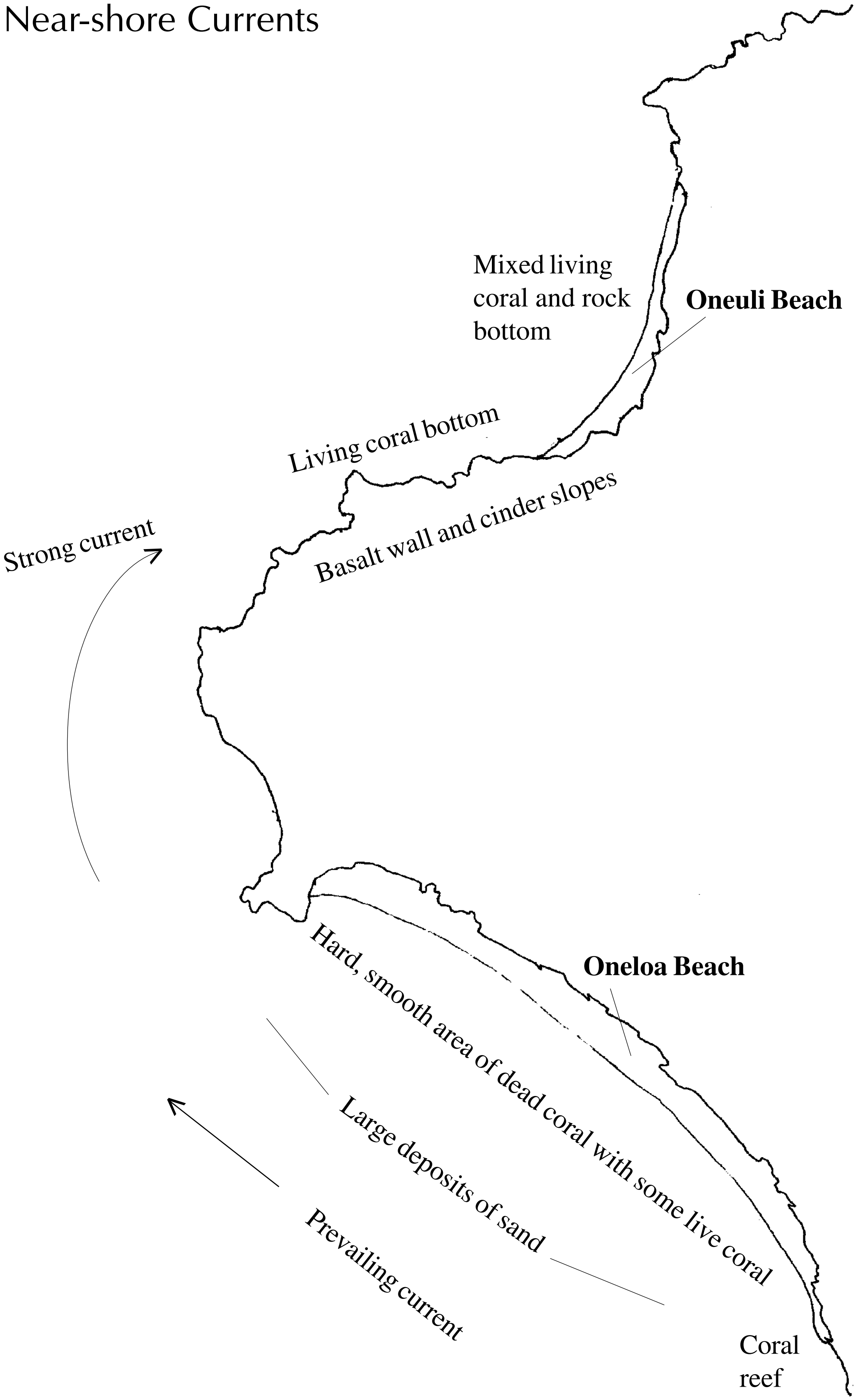
Photos: Ann Fielding

Oneloa Beach

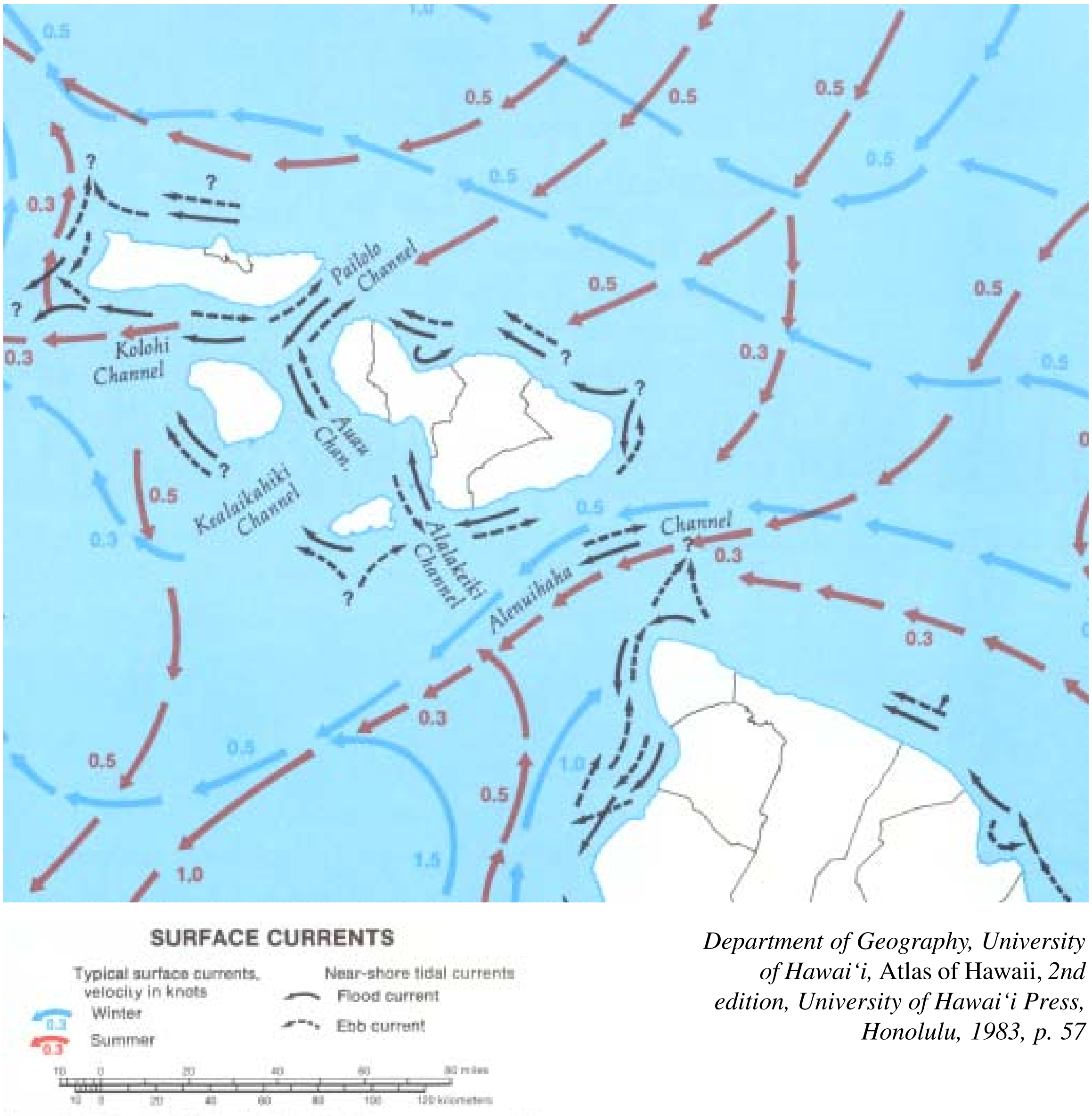
Photos: Ann Fielding

Station #3: Maps Showing Bottom Types and Major Currents

Map of Ocean Bottom Types and
Near-shore Currents

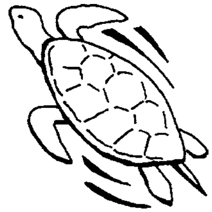


Map of Major Ocean Currents Around Maui



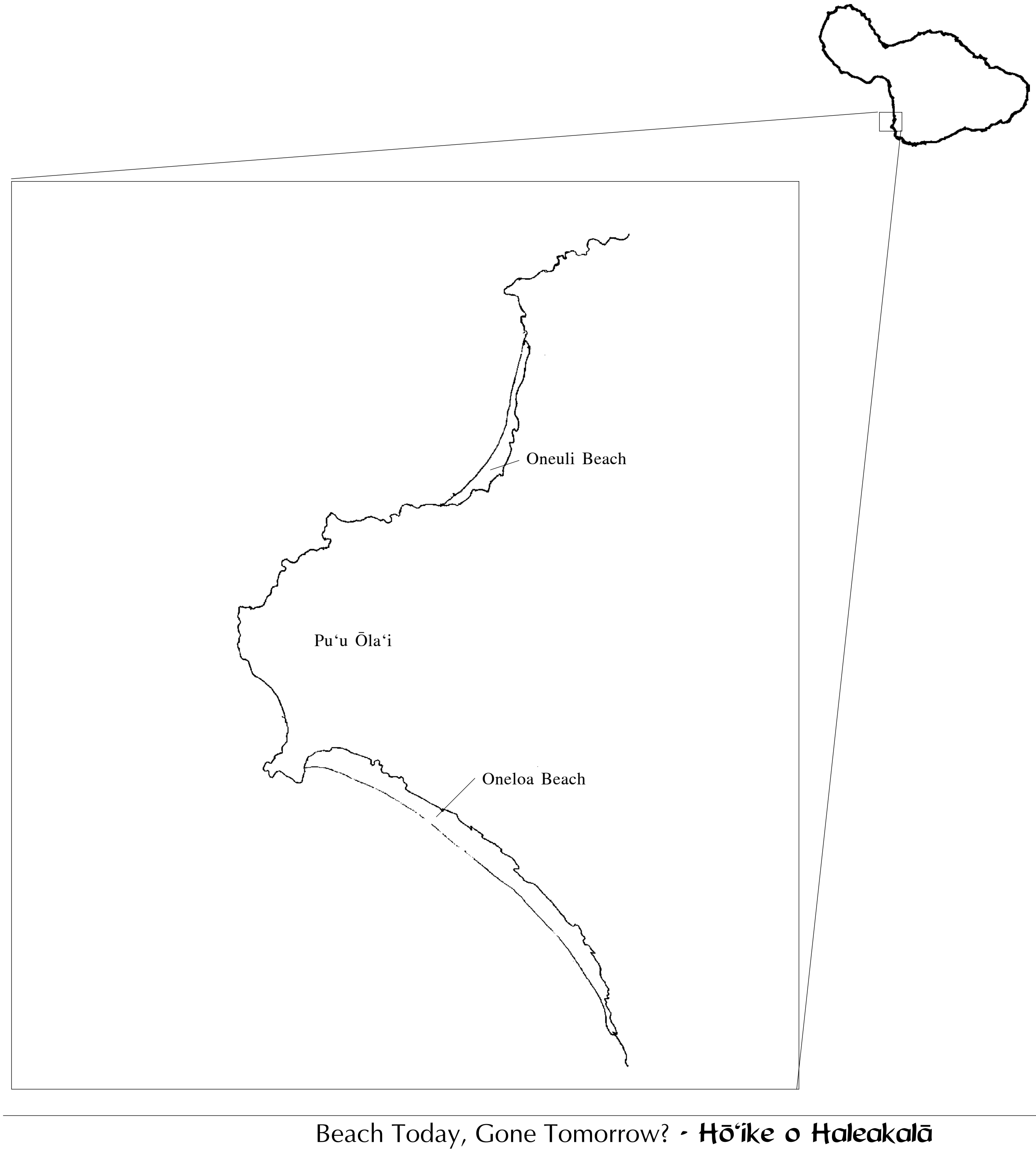
Source: Hawaii Institute of Geophysics, University of Hawaii 1982

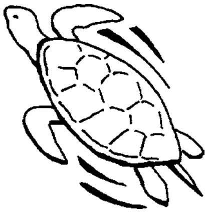
Department of Geography, University of Hawai'i, Atlas of Hawaii, *2nd edition, University of Hawai'i Press, Honolulu, 1983, p. 57*



Where Does the Sand Come From?

Read the questions that follow the map. Use the maps and graphics at the information stations to help you answer them. Record relevant information from those maps and graphics onto this page. Make additional sketches and notes as needed.



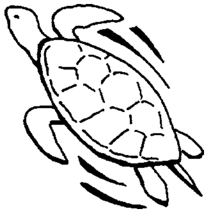


1) Where does the sand on Oneuli beach come from?

2) Where does the sand on Oneloa beach come from?

3) What factors may explain the differences in sand composition and particle size between the two beaches?

4) What additional information would you need to have to be more confident in your hypotheses? How could you collect that information?



Activity #3

Causes and Consequences of Coastal Erosion

● ● ● **In Advance** *Student Reading and Questions*

- As homework, assign the Student Pages "Beaches on a Budget: Why Do Beaches Come and Go?" (pp. 42-45) and "Beaches on a Budget: Questions About the Reading" (pp. 46-48).

● ● ● **Class Period One** *Coastal Erosion Projections*

Materials & Setup

For each lab group of three to four students

- "Baldwin and Kanahā Beach Aerial Photo" acetates (master, pp. 40-41)
- Baldwin and Kanahā "Beach Study Maps and Graphs" (legal-size masters included with this curriculum). Each lab group should have the information that corresponds to its assigned beach.
- Two copies of the Student Page "Coastal Erosion Projections" (pp. 49-51)
- Overhead projector
- One sheet of legal-size or larger paper
- Colored pens or pencils
- Masking tape

For each student

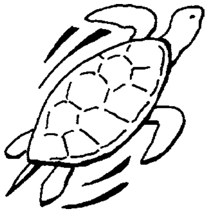
- Student Page "Beaches on a Budget: Why Do Beaches Come and Go?" (pp. 42-45)
- Student Page "Beaches on a Budget: Questions About the Reading" (pp. 46-48)
- Student Page "Beach Management Alternatives" (pp. 52-53)

Instructions

1) Review student questions and responses to the homework, especially question #7 in which they explained the impact of shoreline armoring and longshore currents on beach erosion and accretion. This question is designed, in part, to help students understand how longshore currents transport and deposit sediment along coastlines, and how disrupting this current can lead to changes in the normal patterns of beach erosion and accretion.

2) Divide the class into lab teams of three to four students. Give each team a copy of the Beach Study Map and Graph for *either* Kanahā or Baldwin beach.

3) Explain that the black-and-white photos and maps are excerpts from a study published in 1991. The study looked at coastal erosion by comparing aerial photos taken in 1950, 1964, 1975, 1987,



and 1988. At each of several transects, the authors calculated the rate of coastal erosion during intervals between photos. They looked at the changing location of the coastal vegetation line to track erosion and accretion. The results are presented in the graphs that accompany each map.

4) Project the “Baldwin Beach Aerial Photo” and “Kanahā Beach Aerial Photo” acetate onto the groups’ legal-sized or larger papers taped to the wall. Have each group trace its assigned beach from this image, including the water line and the vegetation line, along with any shoreline armoring that appears on the map and important reference points such as roads or large, recognizable facilities. Students can use the line-drawn maps from the 1991 study as a guide for which features could be useful to include on their tracing. When they have finished tracing the color image, they should add and number the transect lines from the corresponding “Beach Study Map and Graph.”

5) Have students complete the steps and answer the questions on the Student Page “Coastal Erosion Projections.”

6) After lab groups finish their work, have a class discussion to compare results and talk about how these kinds of projections can contribute to coastal management decisions.

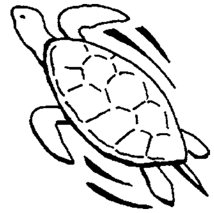
7) Assign the Student Page “Beach Management Alternatives” as homework.

Journal Ideas

- How should projections for future shoreline erosion affect people’s decisions about where and how to build houses, hotels, condominiums, roads, and other structures?
- How far into the future do you think people should look when weighing the benefits and drawbacks of shoreline armoring such as seawalls and groins?

Assessment Tools

- Student Page “Beaches On a Budget: Questions About the Reading” (teacher version, pp. 35-37)
- Traced paper maps (evaluate for neatness and accuracy)
- Student Page “Coastal Erosion Projections” (teacher version, pp. 38-39)
- Short paper describing how Baldwin or Kanahā beaches should be managed
- Participation in group work and class discussion
- Journal entries



Teacher Version

Beaches on a Budget: Questions About the Reading

1) What is an active beach?

The part of the beach where sediment transport occurs

2) What is the opposite of shoreline erosion?

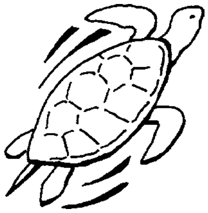
Accretion

3) Explain the term "littoral budget," using at least two examples of sources and sinks.

A littoral budget is the amount and movement of sediments to and from the shoreline—between different parts of the active beach, onto the beach from elsewhere, and away from the beach to another location offshore or down-current.

Sources include
- skeletal material from coral reef ecosystems,
- offshore deposits of sand that may be transported onshore by waves and currents,
- other beaches from which longshore currents and wind can transport sediments,
- erosion of headlands and coastal uplands,
- materials from new volcanic eruptions and lava flows, and
- sediments carried from inland by streams and rivers.

Sediment sinks include:
- loss of sediments to deep water;
- harbors and channels, which trap sand moving along or across the near-shore area;
- transport of sediments offshore or along the shoreline to other beaches by currents and waves;
- impoundment (trapping) behind seawalls, revetments, and other structures;
- over-wash by high storm waves and surges; and
- wind loss inland due to strong onshore winds.



4) Describe the cycle of sand dune building, scarping, and rebuilding that happens during and after large storms.

High waves during storms and large swells erode the beach. And they erode the dune, too. This process, known as scarping, releases sand that was stored in the dune to the active beach. The influx of sand from the dune is often carried offshore where it accumulates into sandbars. These sandbars intercept large waves before they reach shore, lessening their impact on the coastline.

When the high-wave event subsides and normal wave patterns return, the waves dismantle the offshore sandbars and rebuild the beach. Although some sand may have been permanently washed away from the beach system into deep water by the storm, eventually the beach and the dunes regenerate to their prestorm profile. Most of the sand transported offshore during storms and stormy seasons eventually is reincorporated into the dune.

5) Name two reasons why coral reefs are important to healthy beaches.

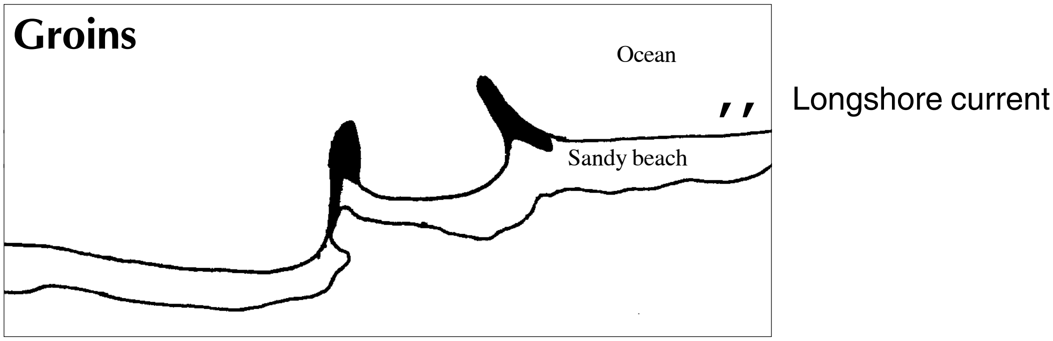
- They act as natural breakwaters, absorbing wave energy and helping protect the shoreline from wave erosion.
- They are important sources of sand production.

6) Describe two human activities that aggravate coastal erosion and reduce the amount of sand available to the beach.

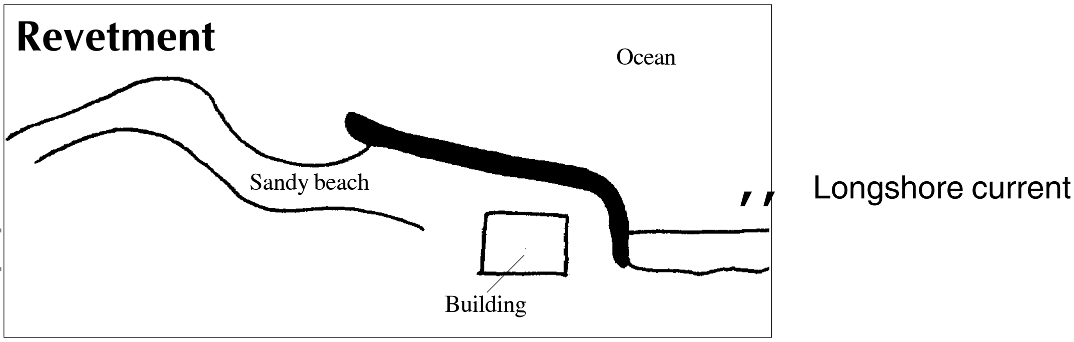
Activities include
- Shoreline armoring,
- Sand mining,
- Grading dunes, and
- Maintaining and expanding harbors and navigational channels.

See Student Page “Beaches on a Budget” (p. 44) for descriptions of each activity.

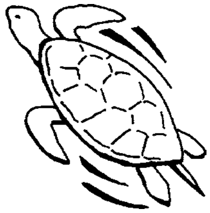
7) True to their name, “longshore” currents run along or parallel to the shore. These currents are important mechanisms for transporting sediment within the beach system. Sediment transported along shore feeds beaches along the entire coastline. Shoreline armoring interferes with longshore sediment transport. The diagrams below illustrate two different types of shoreline armoring that have been in place for several years. For each diagram:
   a) Draw in the direction of the longshore current, and
   b) Explain how the pattern of beach erosion and/or accretion is related to the armoring structure and the longshore current.



The groins have trapped sand behind them, causing accretion on the up-current side while robbing down-current beaches of their normal source of sediment transported by longshore currents.



The beach area just down-current from the revetment is heavily eroded because the revetment cut off a continuing source of sediment for the longshore current to pick up and deposit there.



Teacher Version

Coastal Erosion Projections

Use your traced paper image of your beach and the space provided on this page to project changes in the coastline over time.

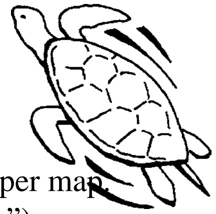
BEACH NAME: ___________________________________

1) The 1991 study graphs changes in the vegetation line between 1950 and 1988. For each transect on your beach segment, calculate an average annual rate of change, and record your calculations and answers below:

Transect #	Annual rate of change (+ or -)
Kanahā 5	-1.5 ft/year
6	-4.74
7	-4.08
8	3.53
9 (not on aerial photo)	5
Baldwin 17	.47 ft/year
18	-1.1
19	-2.89
20	-.39

2) You are going to be mapping projected shoreline changes based on the annual rate of change you calculated above. You will do this using the 1997 aerial photo (your traced paper image of it) as a baseline. Before you start mapping, you need to do some more calculations. Using the annual rate of change for each transect line, calculate the total erosion or accretion likely to occur by 2027 and 2057. Calculate these changes using 1997 as your starting date.

Transect #	Change (+ or -) by 2027	Change (+ or -) by 2057
Kanahā 5	-43.5 ft	-87 ft
6	-142.2	-284.4
7	-122.4	-144.8
8	105.9	211.8
9 (not on photo	.13	.26
Baldwin 17	14.1 ft	28.2 ft
18	-33	-66
19	-86.7	-173.4
20	-11.7	-23.4



3) Now mark the 2027 and 2057 vegetation lines on each of the transects on your traced paper map. (Extrapolate the scale on your traced paper map using the "Beach Study Map and Graph.")

   Use these points and any clues you can glean from the existing shoreline features to draw an anticipated vegetation line for 2027 and 2057. (Using different-colored pens or pencils for each line helps make the map clearer.)

   With a dashed line, indicate where you think the water line will be in 2027 and 2057.

   Label your map clearly.

4) Looking at your traced paper map, as well as the photos, maps, and information from the 1991 study, describe any patterns of erosion and accretion that you see. What might explain these patterns?

   Well-reasoned responses are acceptable. The primary patterns are associated with shoreline armoring (e.g., accretion up-current and erosion down-current, or even complete erosion of the beach behind the groin).

5) In 1992, researchers estimated that 62 percent of the Maui shoreline is eroding at a rate of 1.25 feet per year. How do the erosion/accretion rates you calculated compare with that average?

   The average rate of erosion taken across all nine transects is 1.16 feet per year, slightly less than the Maui average. However, in certain places, particularly at Kanahā beach, the rates of erosion are much higher than this average, and in other places the shoreline is accreting.

6) Use your projections to identify areas where you think development should be restricted because of the potential for shoreline erosion, and areas that you think would be appropriate for development. Explain your reasoning for these areas here.

   Well-reasoned responses are acceptable

Baldwin Beach Aerial Photo

Photo: Air Survey Hawai'i

Kanahā Beach Aerial Photo

Photo: Air Survey Hawai'i

Beaches On a Budget: Why Do Beaches Come and Go?

Adapted from the Hawai‘i Seagrant website, Beach Plan for Maui*, "Coastal Ecosystems" and "Coastal Erosion, Beach Loss, and Coral Reef Degradation," accessed May 25, 2000 at <www.soest.hawaii.edu/SEAGRANT/bmpm/coastal_ecosystems.html> and <www.soest.hawaii.edu/SEAGRANT/bmpm/coastal_erosion.html>.*

Long stretches of sand usually come to mind when we hear the word "beach." But a beach is actually an accumulation of any sediment along a coastline. A sediment is any material that is deposited by waves. Usually that is sand or gravel, but there are mud beaches and beaches made up of much larger rock fragments, too. The make-up of a beach depends on the type of sediment available and on the ability of the waves, tides, and currents to move it.

Beaches are naturally dynamic, changing from wave to wave, season to season, and year to year. That is because wind, waves, and currents move the sediments around. The part of the beach where sediment transport occurs is called the "active beach." As the figure below shows, the active beach is divided into three parts: the backshore, foreshore, and offshore. Behind the active beach is the coastal upland. This upland might be a dune, a cliff, a constructed seawall, a soil embankment, or another geological formation that provides a landward barrier for the beach.

Beaches on a Budget

Each beach has a "littoral budget." "Littoral" refers to the shoreline. The "budget" is the amount and movement of sediments between different parts of the active beach, onto the beach from elsewhere, and away from the beach to another location offshore or down-current. Healthy beaches have balanced budgets—the net influx of sediment equals the net loss of sediment. It's like earning and spending the same amount of money in a month.

Where do the sediments come from and where do they go? Coastal geologists refer to "sources" and "sinks" of beach sediment. Sources include:

- Skeletal material from coral reef ecosystems,
- Offshore deposits of sand that may be transported onshore by waves and currents,
- Other beaches from which wind or currents that run along the shoreline can transport sediments,
- Erosion of coastal uplands and points of land that jut out into the ocean,

Photo: Ann Fielding

- Materials from new volcanic eruptions and lava flows, and
- Sediments carried from inland by streams and rivers.

Sediment sinks include:

- Loss of sediments to deep water,
- Harbors and channels, which trap sand moving along or across the near-shore area,
- Transport of sediments offshore by currents and waves to underwater “sand banks” from which beaches can be replenished seasonally or after large storms,
- Transport of sediments along the shoreline to other beaches by currents and waves,
- “Impoundment” (trapping) behind seawalls, revetments, and other structures,
- Over-wash by high storm waves and surges, which flush sand inland where it cannot be redeposited onto the beach, and
- Wind loss inland due to strong onshore winds.

When there is an imbalance between sources and sinks, the beach will either erode or “accrete” (build up).

The Beach System

Many of the sandy beaches on Maui are part of a beach system that includes dunes and coral reefs, as well as the beach itself. Each element of the whole system is important in the natural cycle of beach erosion and accretion.

Beaches naturally erode and accrete in cycles that correspond with seasonal weather changes and episodic storm events. During a storm, or through the course of a high-wave season, nearly all of the sand may seem to disappear from a beach, and the dune may be almost entirely washed away.

But after a couple of weeks or a few months of calmer weather, the beach and dunes rebuild. On undeveloped beaches, this cycle usually results in the complete rebuilding of the beach and dune profile to what it was like before the storm event or high-wave season began.

Sand Dunes

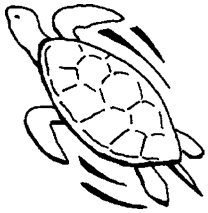
Along the coast, just as inland, dunes are accumulations of windblown sand. Some coastal dunes are unvegetated, but most are covered with coastal plants. The thick root systems of most native plants help hold the sand in place, slowing the rate at which the dune erodes during high winds and waves. Plants such as *naupaka* and beach morning glory also help dunes rebuild by trapping windblown sand and growing up through the new layers of sand to build larger and wider dunes.

Like beaches, dunes are dynamic. They erode during times of high waves and accrete during normal wave conditions. Dunes are like sand savings accounts for beaches. High waves during storms and large swells erode the beach. They erode the dunes, too. This process, known as “scarping,” releases sand that was stored in the dunes to the active beach. The influx of sand from the dunes is often carried offshore where it accumulates into sandbars. These sandbars intercept large waves before they reach shore, lessening their impact on the coastline.

When the high-wave event subsides and normal wave patterns return, the waves dismantle the offshore sandbars and rebuild the beach. Sand blown inland from the beach can then rebuild the dunes. Although some sand may have been permanently washed away from the beach system into deep water by the storm, eventually the beach and the dunes regenerate to their prestorm profile. Most of the sand transported offshore during storms and stormy seasons is eventually reincorporated into the dune.

Coral Reefs

Coral reefs act as natural breakwaters in the beach system. They absorb much of the incoming wave energy and help protect the shoreline from wave erosion. Coral reefs and the invertebrates



and algae they support are also important sources of sand production for beaches as the skeletons and other hard structures they produce are eroded by waves and animal activity. Most of the light-colored sand on beaches comes from coral reef ecosystems. Because coral reefs buffer waves and produce sand, they slow the rate of coastal erosion and beach loss.

Interfering with Nature

Coastal erosion is at least partly a natural process. One contributing factor is the rising sea level. Since the last ice age, the sea level has risen nearly 110 meters (361 feet), and as it rises, the whole littoral (shoreline) system moves further inland. Coastal uplands are eroded, and the influx of sediment released to the active beach helps maintain the beach width. We can expect that coastal erosion will continue as sea level rise is currently averaging 2.5 centimeters (about one inch) per decade on Maui.

But sea level rise is only one cause of changing coastlines, and not the most visible and dramatic cause. In many cases, coastal erosion has been aggravated by human activities that reduce the amount of sand available to the beach. Sand mining, dune destruction, and harbor and channel construction, for example, have led to increased rates of coastal erosion on some beaches.

Sand Mining

Taking sand from the beach system leads to beach narrowing and a decrease in sand volume. Until the early 1970s, large volumes of sand were mined from beaches around Maui to provide cement aggregate for construction and lime for sugar cane processing. In fact, on Baldwin Beach, a large structure that once protected the lime kiln from the encroaching sea is now well out in the water because of subsequent coastal erosion.

Dune Destruction

During building construction, dunes are often bulldozed to flatten their tops, allowing better views of the ocean or to make way for construction. Changing the shape of the dunes changes how they respond to storm waves and reduces their ability to serve as a natural buffer. Further, if the dune is then covered with soil for landscaping, future storms will erode the fine sediments of the soil, carrying silt into the ocean.

Dunes are also damaged by people walking or driving over them. This destroys dune vegetation, which is critical to holding the sand in place. A dune with damaged or reduced vegetation cover is more susceptible to erosion and less able to rebuild.

Harbor Construction

Maintaining and expanding harbors and navigational channels change natural patterns of sediment transport. Sand transported by near-shore waves and currents is deposited into these artificial depressions and removed from the littoral system. Also, constructing harbors and channels can entail dredging parts of coral reefs, allowing larger waves to reach the shoreline and accelerate coastal erosion.

Protecting Property

Waves and currents naturally transport sediments along shorelines, within the active beach zone, and sometimes offshore. Episodic and seasonal erosion is a fact of life along the coastlines—and so is the landward migration of the shoreline. But that reality does not always fit well with people's ideas about property. When people build in coastal areas, they want their homes, hotels, roads, and other structures to be standing on solid ground in ten, 50, or 150 years. And we want our beach parks to stay beach parks!

"Shoreline armoring" is a common approach to slowing coastal erosion, stabilizing coastlines, and protecting beachfront property. Armoring structures include "seawalls," "revetments," and "groins" (see the figure on this page for an explanation). These structures usually halt coastal erosion in the immediate area, but they can lead to unintended consequences. On shorelines that have been retreating over time anyway, they often lead to beach loss. You'll see this effect in action during your next class as you map changes in two Maui beaches over time.

Types of Shoreline Armoring

Photo: Dolan Eversole

Seawall

A vertical or near-vertical type of shoreline armoring characterized by a smooth surface

Photo: Dolan Eversole

Revetment

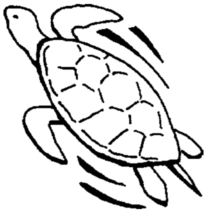
A sloping type of shoreline armoring often constructed from large, interlocking boulders

Revetments tend to have a rougher (less reflective) surface than seawalls.

Photo: Kim Martz and Forest Starr

Groin

A structure resembling a wall, constructed perpendicular to the shoreline and extending into the ocean from the beach

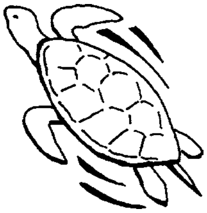


Beaches On a Budget: Questions About the Reading

1) What is an active beach?

2) What is the opposite of shoreline erosion?

3) Explain the term “littoral budget,” using at least two examples of sources and sinks.



4) Describe the cycle of sand dune building, scarping, and rebuilding that happens during and after large storms.

5) Name two reasons why coral reefs are important to healthy beaches.

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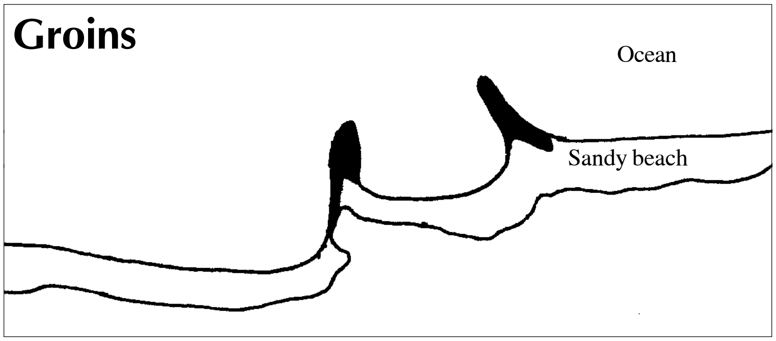
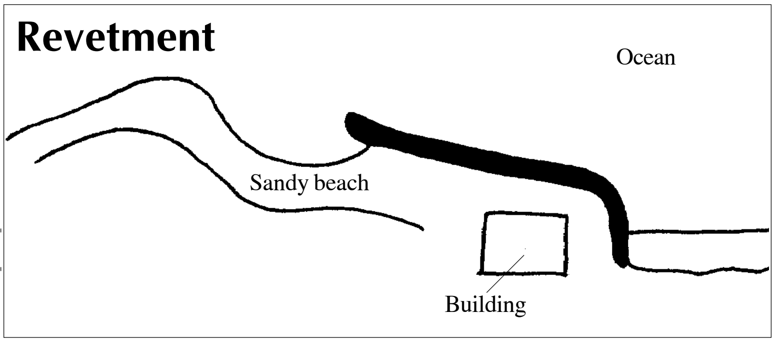
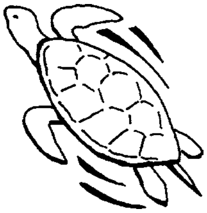
6) Describe two human activities that aggravate coastal erosion and reduces the amount of sand available to the beach.

7) True to their name, "longshore" currents run along or parallel to the shore. These currents are important mechanisms for transporting sediment within the beach system. Sediment transported along shore feeds beaches along the entire coastline. Shoreline armoring interferes with longshore sediment transport. The diagrams below illustrate two different types of shoreline armoring that have been in place for several years. For each diagram:
   a) Draw in the direction of the longshore current, and
   b) Explain how the pattern of beach erosion and/or accretion is related to the armoring structure and the longshore current.







Coastal Erosion Projections

Use your traced paper image of your beach and the space provided on this page to project changes in the coastline over time.

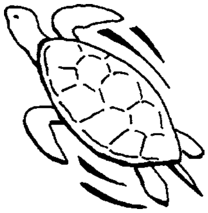
BEACH NAME: ___________________________________

1) The 1991 study graphs changes in the vegetation line between 1950 and 1988. For each transect on your beach segment, calculate an average annual rate of change, and record your calculations and answers below:

Transect #	Annual rate of change (+ or -)

2) You are going to be mapping projected shoreline changes based on the annual rate of change you calculated above. You will do this using the 1997 aerial photo (your traced paper image of it) as a baseline. Before you start mapping, you need to do some more calculations. Using the annual rate of change for each transect line, calculate the total erosion or accretion likely to occur by 2027 and 2057. Calculate these changes using 1997 as your starting date.

Transect #	Change (+ or -) by 2027	Change (+ or -) by 2057



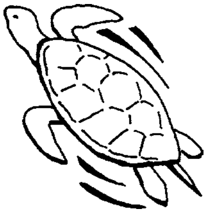
3) Now mark the 2027 and 2057 vegetation lines on each of the transects on your traced paper map. (Extrapolate the scale on your traced paper map using the "Beach Study Map and Graph.")

   Use these points and any clues you can glean from the existing shoreline features to draw an anticipated vegetation line for 2027 and 2057. (Using different-colored pens or pencils for each line helps make the map clearer.)

   With a dashed line, indicate where you think the water line will be in 2027 and 2057.

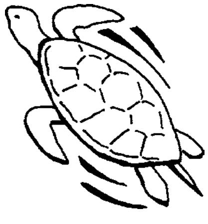
   Label your map clearly.

4) Looking at your traced paper map, as well as the photos, maps, and information from the 1991 study, describe any patterns of erosion and accretion that you see. What might explain these patterns?



5) In 1992, researchers estimated that 62 percent of the Maui shoreline is eroding at a rate of 1.25 feet per year. How do the erosion/accretion rates you calculated compare with that average?

6) Use your projections to identify areas where you think development should be restricted because of the potential for shoreline erosion, and areas that you think would be appropriate for development. Explain your reasoning for these areas here.



Beach Management Alternatives

When protecting coastal property comes at the expense of adjoining beaches, it can set up a conflict that no one really wins—not the property owners, not beach-goers, not the government agencies charged with managing coastal areas, and certainly not the natural system.

There are alternatives. Here are some management tools that are being used to make Maui beaches and coastlines healthier for everyone:

Beach Nourishment

This process is used to create a new sandy shoreline where a beach is eroding or has been lost. It is the only management tool that protects coastal development without degrading the beach.

Beach nourishment involves placing sand fill along the shoreline to widen the beach. The sand may come from inland dunes or coastal plains, or from offshore sources such as dredge spoils from harbor maintenance, and underwater sand fields and banks.

So far on Maui, only small-scale beach nourishment projects have been undertaken, funded by homeowners associations such as Sugar Cove Condominiums in Pāʻia and Kanaʻi o Nalu in Māʻalaea. The sand for these projects has come from inland sand mines that also ship sand to Oʻahu for cement manufacturing.

The potential for beach nourishment on Maui is limited by the availability of high-quality sand. Maui does not have dredging equipment or the knowledge of offshore sources to be able to tap them for nourishing beaches.

Restoring and Protecting Dunes

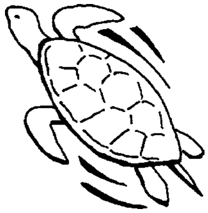
The first step in restoring damaged dunes is usually to erect fences that help trap windblown sand. In 1997, for example, drift fences were erected to restore Keālia Beach's sand dunes. By 1999, sand had buried the fences in spots. Volunteers, including students and adults involved in the Kīhei Canoe Club, took the next steps by helping replant native vegetation on the growing dunes. Native dune plants have dense root systems and spreading vegetation that trap even more windblown sand. They grow up through the new layers of sand to build larger and wider dunes.

Native plants and the dunes they help keep in place are sensitive to trampling. Plants can be uprooted by people walking across dunes going to and from the beach. Another approach to protecting dunes is to build moveable walkways that provide access without the danger of trampling. These walkways can easily be moved when needed.

Building Setbacks

According to the Hawaiʻi Department of Land and Natural Resources document *Coastal Erosion and Beach Loss in Hawaii* at <www.soest.hawaii.edu/SEAGRANT/CEaBLiH.html>, much of the beach loss in Hawaiʻi "could have been avoided if houses were not built so close to the water. The law presently allows homes 40 feet from the shoreline. On coasts experiencing chronic erosion this is too close and leads to hardening [building sea walls and revetments] in order to protect houses from the waves."

"Shoreline setbacks" (the required distance from a structure to the shoreline) are intended to establish a buffer zone to protect beachfront



development from high waves and coastal erosion. In 1990, the Maui County Planning Department revised its rules so that some building setbacks were based on the average depth of the lot, rather than on the state's 40-foot minimum. But according to the Maui Beach Management Plan, more effective setbacks would be site-specific, based on projected shoreline erosion 30, 60, or even 90 years in the future.

Even if coastal erosion hazard maps are not used to guide government rules about building setbacks, these projections could be used to give planners and landowners information that will help them plan and design coastal developments.

Construction Guidelines

Many coastal landowners and developers are not fully aware of shoreline erosion, the potential impacts of development on the beach, and design and construction options that could minimize the threat to their property and the adjacent beach. Consulting with experts and government agencies could help them design projects with minimum impact. Since county and state goverments are aware of the problems associated with coastal development and protection measures such as seawalls and revetments, they need to advise and educate coastal landowners on environmentally compatible alternatives.

In order to choose which strategies to use and where, we need to consider the history of erosion and accretion for each specific stretch of beach. These processes can vary dramatically even from one end of a beach to the other. Knowing more about how each stretch of the coastline has changed over time will help point out areas in which different approaches are most likely to work.

Your Assignment

On a separate piece of paper, write a one- to two-page paper describing how you think either Baldwin beach or Kanahā beach should be managed to protect the beach and the shoreline property behind it. Your paper should include suggested actions and explain your reasoning. In writing your paper, consider your coastal erosion projections for different stretches of this beach.