WAVES, WETLANDS, AND WATERSHEDS

California Coastal Commission Science Activity Guide

CALIFORNIA
COASTAL
COMMISSION

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Waves, Wetlands, and Watersheds is a classroom based hands-on activity guide that integrates California Coastal Commission areas of critical concern (wetlands, coastal processes, marine debris and pollution, and endangered species) with California Science Content Standards for grades three through eight. Also included are community action activities for all ages and grades.

The California Coastal Commission was established by voter initiative in 1972 and made permanent by the Legislature in 1976 with the passage of the California Coastal Act. Its mission is to protect and enhance the resources of the California coast and ocean for current and future generations. In addition to planning and regulatory functions, the Commission carries out a public education program that includes the annual California Coastal Cleanup Day; the Adopt-A-Beach Program; the Boating Clean and Green Campaign; the Waves, Wetlands, and Watersheds school program; and the Whale Tail License Plate Program. The Commission's Whale Tail License Plate gives drivers a way to support California's coast and ocean. Proceeds fund the Commission's public education programs, as well as the Whale Tail Grants Program, which supports marine education at the local level.

For more information, or to order copies of this activity guide, contact the California Coastal Commission: 45 Fremont Street, Suite 2000, San Francisco, CA, 94105, (415)904-5200, *coast4u@coastal.ca.gov,* or *www.coastforyou.org*

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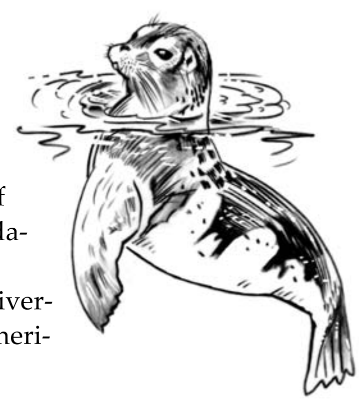


Foreword

The citizens of California established the California Coastal Commission through a voter initiative in 1972. They recognized that the coast is a great treasure and should be preserved for us all. This belief remains a core value in our state and the Commission continues to work to maintain accessible, healthy beaches, and clean, productive ocean waters.

Increasing the public's knowledge and understanding of coastal and marine resources is an important aspect of this work. The more that people know about the coast and ocean, the better able they are to care for these ecosystems. When we introduce our young people to the ocean and its beaches, we shape tomorrow's coastal stewards.

The ocean provides us with food, helps create our weather and climate, shapes our land, and serves to connect us to distant nations and peoples. It is a place of refuge, contemplation, and inspiration. For all these reasons and more, it is important for California's children to understand and respect this powerful force. This science activity guide furthers that goal.

As we learn the value of the ocean, it becomes clear that its health is dependent upon the health of the land that borders it. California's watersheds, rivers, and wetlands all affect the coastal environment with its many plant and animal species, and in turn affect the ocean itself. Even inland communities have a responsibility for and a stake in the health of the ocean. It is my hope that all citizens of our state will learn to understand and appreciate this fascinating resource and join in efforts to protect, preserve, and restore California's coast and ocean for many generations to come.

Mike Reilly
Chair, California Coastal Commission, 2003

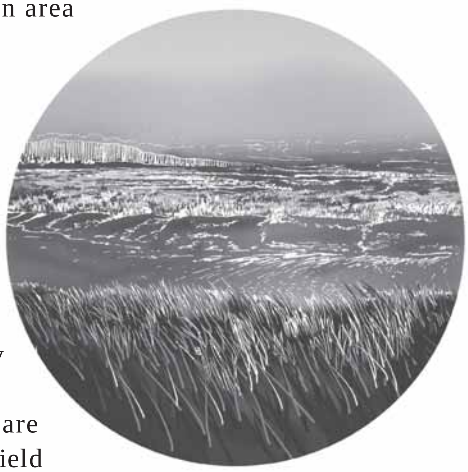
Chapter 1
Introduction

Welcome to a book that may give you a new perspective on our state. From the snow-capped peaks of the Sierra Nevada, to our warm, sandy southern beaches and our rugged, wind-swept north coast, our stunningly beautiful state supports a bounty of life and a diversity of habitats. This diversity presents an outstanding opportunity to witness science in action, regardless of where you live. We all live in a watershed, and almost all watersheds ultimately empty into coastal waters. *Waves, Wetlands, and Watersheds* will help students understand the natural systems that connect all Californians to our coast, whether they live on the San Joaquin River, on the shores of Lake Tahoe, or in the middle of Los Angeles.

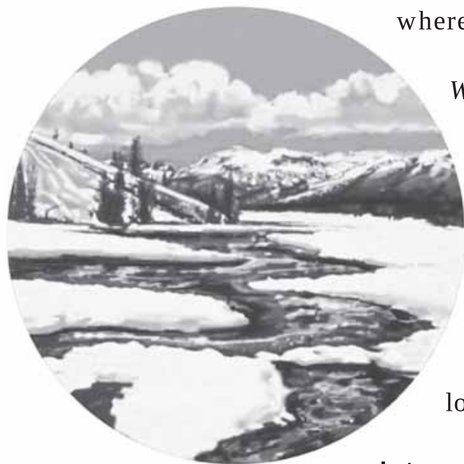
California's natural resources have provided a robust livelihood for its human inhabitants for hundreds of years. We continue to rely upon those resources for food, housing, clothing, and entertainment. Like a family heirloom passed from mother to daughter, California's natural heritage can be cherished and polished from generation to generation. However, it is human nature to take care only of what we understand to be valuable. These activities use an inquiry-based learning approach to develop this understanding. Once students comprehend how natural systems work, and their role in the continued function or ultimate collapse of these systems, they have taken their first step to protecting and conserving California's valuable resources.

Activity Focus

These activities were adapted from exemplary time-tested science curricula developed by outstanding environmental and scientific organizations. The hands-on activities were evaluated and selected based on three criteria: they concentrate on an area of critical concern to the California Coastal Commission (wetlands, coastal processes, rare and endangered species, nonpoint source pollution, and marine debris), they address multi-disciplinary standards (science content, language arts, mathematics, and history-social science) for California students in grades 3-8, and they are designed to be accessible to all students as no expensive materials are necessary and only one requires a field trip (grade 6). Community Action activities (Chapter 9) can be used by all grade levels, as they do not directly address science content standards but encourage students to become more aware of marine pollution sources and participate in efforts to address the problem.



The activities serve many academic and community needs. They provide students with classroom experiences that bring to life the sometimes static textbook descriptions of scientific concepts. Students will build their knowledge using models just like the scientists use, and learn about real life adventures of California's plants and animals. The activities engage students and promote conceptual learning because they provide hands-on experiences that exercise both creative and critical thinking skills. The activities are presented within a local context that links students' backyards and neighborhoods to the coastline, no matter where they live.



Waves, Wetlands, and Watersheds follows many of the teaching and learning practices recommended for California teachers as in *Making Connections: A Guide to Implementing Science Standards* (California Science Teachers Association, 1999). These include inquiry-based teaching and learning, an integrated science approach that assists understanding of how systems work rather than isolated fact memorization and recitation. Most importantly, the activities promote teaching and understanding of basic concepts by encouraging students to gather information, look for patterns, and then make sense of the patterns.

Integrating Activities into Your Curriculum

Through studying the environment, students learn not only the scientific basis for natural phenomena, they also learn the roles that people (and they themselves) play as they interact with the world around them. In this way, *Waves, Wetlands, and Watersheds* can be used to convey a broad range of concepts. Since each activity specifically addresses at least one Science Content Standard (and many also address standards in other disciplines), teaching about the environment can fit seamlessly into your curriculum. For instance, if you are a third grade teacher, you can teach about wetland habitats and species while covering the concepts of adaptation and survival (Science Content Standard 3, Life Sciences). Depending upon time and the degree of student interest, you may begin with simpler concepts and then build up to the larger, in-depth issues and extensions.

Chapter 2
How-to Guide

How to use this book

There are three activities for each grade level from third to eighth grade. The last chapter, *Chapter 9: Community Action*, has activities that may be adapted for use by all grade levels from first to twelfth. All activities in a grade level fall under the same science topic or theme. Each activity within a grade level may be completed independently of the other activities. Following is the format in which the pages are organized.

Activity

Details on how to conduct activity. Includes scripts for leading a classroom discussion, information on how to assemble stations, and the sequence of steps to complete the activity.

(indicates new activity)

Results and Reflection

Activity wrap-up and discussion. Worksheets may be used for assessment and evaluation.

Conclusions

The big picture your students will understand by this point. The "take home" content information.

Extensions and Applications

Does this activity interest your students? Want to go further? Do more? Field trip ideas, research papers, topics for further whole class discussions, and how to become more involved in the community.

Adapted from

The citation of the original activity including contact information. If you like this activity, you may wish to contact the organization to obtain a complete list of their curricula. This section also includes additional references where appropriate.

Science skills

The actions students undertake to complete this activity.

- observing: using all five senses
- classifying: identifying like and unlike objects, grouping into sets
- measuring: using numbers to describe size, weight, quantity, volume, or time
- organizing: analyzing and interpreting data
- inferring: drawing conclusions from data
- predicting: forming hypotheses based on past observations and results
- experimenting: identifying and controlling variables in testing hypotheses
- deducing: deriving a conclusion from something known or assumed
- communicating: verbal, written, or other methods of informing others about results and conclusions

Concepts

Underlying themes or understandings to be revealed by the activity. A concept shows relationships. For example, "Wetlands support life forms that have adapted to a part wet, part dry habitat."

(*proceed to next page*)

California Science Content Standards

Also listed are language arts, mathematics, and history-social science standards where appropriate.
According to the *Introduction to the California Science Content Standards*, the standards represent the essential skills and knowledge in science that students are expected to have acquired at each grade level. The content within each grade or span is organized into strands.

For grades K-5, the science content strands are Earth Science, Life Sciences, Physical Sciences, and Investigation and Experimentation. For grades 6-8, the content is organized in concentrations, with a focus on Earth Science in grade 6, Life Science in grade 7, and Physical Science in grade 8. *Standards listed in each of these activities are only those that are specifically addressed in the activity.*

Vocabulary

New words and concepts

Objectives

Measurable student learning goals of the activity.

Time to complete

An estimate—may be different depending on class reading level or other variables. Does not include setup or cleanup time.

Mode of instruction

Synopsis of how the activity proceeds, from whole class discussion to results and reflections.

Materials

Detailed list of what is needed to complete the activity, including worksheets.

Preparation

Overview of what to expect in completing the activity, what to plan for in advance.

Outline

What to do a week before, day before, day of the activity. A "to-do" list.

(*end of column*)

Final Tips

Throughout the activity guide you will find boxes similar to this that contain information you may use to get more out of the activity. The information is usually optional–gauge your class's level of interest first and then decide whether to use the additional facts. Here are some final notes on how to use the book.

To conduct the activity, first check the left column. It contains preliminary information to decide how to arrange the time, facilities, and materials to do the activity. Look down this column to get an overall view of the activity. Once you have decided where it fits into your yearlong curriculum, read the background and activity description in the wider column to the right. This column gives you the "how-to" of the activity, from how to open a whole class discussion on the topic, to how to conduct the demonstration or assist students in their own experiments, to the activity wrap-up, and finally to the results and reflections, and optional extensions.

Most activities may be carried out within a one-hour class period. Some will take longer, some shorter, and a few can be continued over a number of days. Some of the activities require ordering videos from the Coastal Commission a few weeks in advance; this is noted in the "Preparation" section. Most activities can be completed within the confines of your classroom or schoolyard, using materials readily obtainable. No materials must be ordered from a scientific supply house, and most can be picked up at a grocery or hardware store. Have fun with these activities, and let us know how they turned out for your class. E-mail your comments to us at *coast4u@coastal.ca.gov*, and be sure to visit our website at *www.coastforyou.org* for updates and more information.

Chapter 3
Some Like It Wet

Earth is home to many creatures with many different needs, from polar bears to snakes. Everything that lives on Earth lives in a *biome*. A biome is an area of land with special plants, animals, climate, and soil. There are many different biomes on Earth. A wetland is a biome, so is a redwood forest and a desert. Biomes have plants and animals that, over time, have grown together to help each other live in their homes, whether their homes are a deep, wet jungle or a dry, sunny desert. Biomes contain a number of habitats that are specific to each biome. Here we will learn more about the wetland biome, the special *adaptations* of plants and animals who live in wetlands, and the many ways wetlands have been used in the past.

New words
biome; wetland; adaptations; species; water table; ecosystem; habitat; environment; rare, threatened, and endangered species

Wetlands, also called marshes, are part water and part soil. Sometimes they are covered with water, and other times they look dry but still have water hidden in the soil. Wetlands are found on our coast, near lakes, ponds, rivers and streams, and in inland mountains and river valleys. They can be salt water, fresh water, or a mix of salt and fresh, called brackish water. You may even have a wetland near your home or school.

Wetlands are one of California's most beautiful biomes, and one of its most special. Because wetlands are the place where land meets water, they provide habitat for plants and animals that live on land and in the water. Wetlands also have important jobs. Water that rushes off land during storms is slowed down when it hits wetlands, where it stays awhile before more slowly entering the ocean or larger bodies of water. Plants and animals thrive in this calm water, and use it for breeding and as a nursery for their young. On the coast, wetlands protect low-lying areas from storm waves—they slow the waves down before they hit dry land. Wetlands provide food and shelter for birds, young fish, small bugs, and other tiny creatures.

The birds, animals, and plants that live in wetlands have special *adaptations* to live in a part dry, part wet world. They have special body types and habits that help them eat and nest in wetlands. Wetland plants and animals rely on each other—they are all part of the wetland food chain. They can't live in a place that is all wet, such as a pond, or all dry, such as a meadow. The water and soil mixture has to be just right for a wetland to be a good home for wetland *species* (plant and animal types). Wetland species have some special adaptations, such as some wetland birds' beaks are just the right length to dig for bugs and worms that live in the mud under shallow water. And bees that live in a dry habitat nearby pollinate some wetland plants. Without these bees, the plants would not survive. These adaptations make wetland species special—many of these species can live no

California Coastal Commission Area of Critical Concern: Wetlands

Relevant California Science Content Standards, Grade 3: Life Sciences 3. a.-d

Grade 3 Activities

These activities will help students learn more about the roles wetlands serve as habitats, about a salt marsh food chain, and how some birds have adapted to become very picky eaters, limiting them to the habitats in which they can survive.

Activity Goals

3.1 Wetlands at Work

Students will:

1. Understand the beneficial functions of wetlands and how they are related to the students' needs.
2. Know that wetlands are a biome with unique habitats for many plants and animals.
3. Understand that wetlands have been used over the course of California history, and are considerably changed today.

3.2 Marsh Munchers

Students will:

1. Learn about the ecological roles salt marshes play.
2. Reinforce understanding of the concept of a food web.
3. Use body movement and pantomime to simulate the feeding motions of marsh animals and identify their interconnectedness in a food web.

3.3 Fill the Bill

Students will:

1. Understand the concept of adaptation.
2. Learn how adaptation in birds can lead to limitations in what they can eat and where they can live.

place other than wetlands. In fact, wetland habitats are home to 43 percent of the federally listed endangered and threatened species.

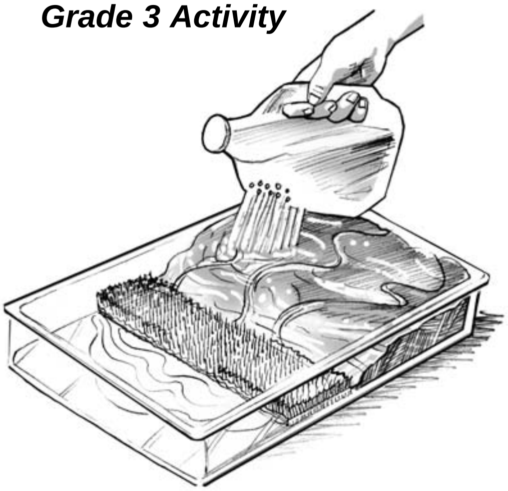
Wetlands are important places for birds that migrate with the seasons. These birds travel long distances and need a safe place to rest and pick up a bite to eat along the way. Wetlands serve this purpose.

Huge flocks of migratory birds use freshwater marshes, but their numbers have been declining because of the activities of humans. The largest remaining fresh water marshes in California are the Creighton Ranch Reserve, a relict of Tulare Lake, the San Joaquin Marsh Reserve in Orange County, and the Gray Lodge north of Sutter Buttes, the most intensively used wetlands in the Pacific Flyway. Freshwater marshes once covered the Great Central Valley, where runoff from the mountains accumulated in basins.

Today, many wetlands are near big cities that are growing fast. In the past, the value of wetlands was not well recognized, so people often filled them in with dirt to create more buildable land. As a result, a lot of wetlands were destroyed, and many of the plants and animals that depend on wetlands have become rare or endangered. A plant or animal is *rare* or *endangered* if it is in danger of becoming extinct soon. Nearly 75 percent of rare or endangered bird species rely on wetland habitats. See the concept map on page 12 to see how the many facets of wetlands relate to each other, and to us.

To protect wetland plants and animals, the state of California has created laws that limit the amount of development that can occur in wetlands. This way, wetlands can still do their many important jobs: provide homes and nurseries for specialized plants and animals, slow down water when it runs off from land, protect coastal areas from big waves, filter out sediments and contaminants, and be wonderful, peaceful places for us to enjoy.

Grade 3 Activity



Science skills

- Gathering and analyzing information
- Predicting
- Experimenting

Concepts

- Wetlands are important parts of California watersheds.
- Wetlands protect our coast.
- Wetlands slow down water runoff, filter it, and release slowly over time.
- Wetlands support life forms adapted to a part wet, part dry habitat.

California Science Content Standards

3. Life Sciences

Adaptations in physical structure or behavior may improve an organism's chance for survival. As a basis for understanding this concept:

3.b. Students know examples of diverse life forms in different environments, such as oceans, deserts, tundra, forests, grasslands, and wetlands.

3.c. Students know living things cause changes in the environment in which they live: some of these changes are detrimental to the organisms or other organisms, and some are beneficial.

3.d. Students know when the environment changes some plants and animals survive and reproduce; others die or move to new locations.

Activity 3.1
Wetlands at Work

Students learn what makes a wetland, and observe or create a model that demonstrates the buffering and filtering effects of wetlands.

Background

Most of California's wetlands have already disappeared from the landscape, and only now are we beginning to see the consequences and realize the importance of this previously overlooked habitat. Wetlands serve critical biological and physical functions.

Biological functions of wetlands include:

- Wetlands are a source of *high primary productivity and habitat* for year round and migrating bird and fish species.
- Wetlands have important roles in *providing for humans*; they provide recreation, flood protection, water quality maintenance, and food.
- Wetlands are *nurseries* for 75-90 percent of all the fish and shellfish harvested in America. This natural resource accounts for $111 billion dollars in sales and provides one and a half million jobs.

Physical and hydrological functions of wetlands include:

- *flood control* in low-lying areas; they act as protective natural sponges by capturing, storing, and slowly releasing water over a longer period of time.
- *storm buffers*: coastal marshes can dissipate wave energy.
- *reduce erosion*: wetland plant roots hold soil in place, reducing erosion caused by tidal action.
- *ground recharge to aquifers*: freshwater wetlands collect water.
- *improve water quality*: wetlands act as sediment sinks, effectively trapping, precipitating, and recycling waterborne constituents from run-off. Wetland plants remove small amounts of nutrients, trace metals, and other compounds and incorporate them into plant tissue. Artificial wetlands are used to treat wastewater.
- *contribute oxygen*: the highly productive wetland plants contribute oxygen to the atmosphere through photosynthesis.

This activity focuses on the physical and hydrological functions of wetlands—how wetlands work from the ground up. Because of the unique factors that create wetlands over time, a balance is created of soil, moisture, and plants. Once wetlands are permanently drained, the conditions that created such productive soils are lost, along with their benefits, and once a wetland is altered this balance is difficult to restore. Understanding the unique natural features found only in wetlands reveals why they are so important to plants and animals, including humans.

This activity is divided into two sections, *Build a Working Wetland* and *From Marsh to Marina.* Because of the length of the activities, it is advised to conduct them on different days.

California Mathematics Content Standards

Number Sense

3.2. Add and subtract simple fractions (e.g., determine that 1/8 + 3/8 is same as 1/2). (Extension #2.)

California English-Language Arts Content Standards

Writing

1.1. Create a single paragraph:
a. Develop a topic sentence.
b. Include simple supporting facts and details. (Extension #4.)

2.2. Write descriptions that use concrete sensory details to present and support unified impressions of people, places, things, or experiences. (Extension #4.)

California History-Social Science Content Standards

3.1.1. Identify geographical features in their local region (e.g., deserts, mountains, valleys, hills, coastal areas, oceans, lakes). (Extension #3.)

3.1.2. Trace the ways in which people have used the resources of the local region and modified the physical environment (e.g., a dam constructed upstream changed a river or coastline).

Vocabulary

Runoff, flood retention, sedimentation, wetland buffer, basin, soil erosion

Objectives

Students will:

- Define and identify a wetland.
- Understand that wetlands are a biome with unique habitats for plants and animals.
- Identify the beneficial functions of wetlands to the ecosystem.
- Relate the beneficial functions of wetlands to their daily lives.

Activity 3.1a
Build a Working Wetland

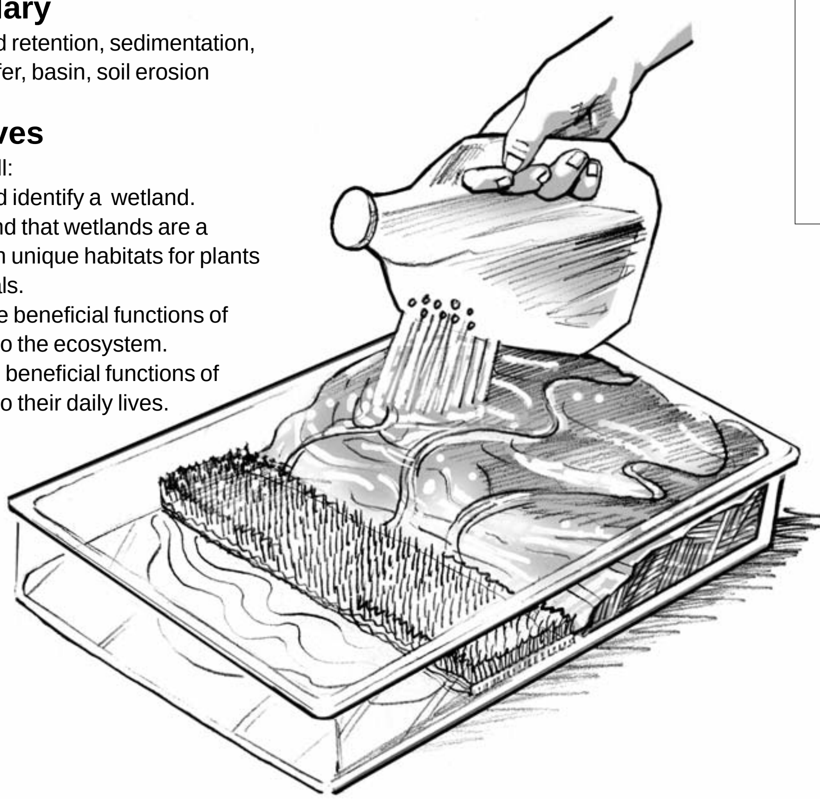
Note: this activity may be completed as a teacher-led demonstration or a small group hands-on activity (small group activity, 2-4 students per model, is recommended). Adjust instructions to meet either case.

1. Ask students what they know about wetlands. What is a wetland? Have they ever been to one? Are they large or small? How can you tell if someplace is a wetland? Students will learn what a wetland is and why wetlands are special places. *Wetlands have unique qualities: part wet, part dry; shallow basins that collect water. Wetlands perform important functions: filtering pollutants and sediments from runoff, reducing flood damage, and preventing soil erosion. Wetlands provide a special habitat for plants and animals adapted to a part wet, part dry environment.* Project the concept map (see "Wetlands at Work" worksheet) on an overhead projector and discuss with students.

2. Create a wetland model or provide materials for students to create their own. Discuss its features (*sprinkling can is rain, clay is watershed, carpeting or sponge is wetland, and catch basin is water body or ocean at end of the watershed*). The model will demonstrate these functions. **PREDICT**. If we make it "rain" on the watershed before we put in the wetland, what do you think will happen to the rainwater? (*Rain runs downhill and pools up at the lowest end.)*

Make a Wetland Model

1. Spread layer of modeling clay in half the pan to represent land. Leave other half empty to represent lake or ocean.
2. Shape clay in pan to gradually slope down to water. Smooth along sides of pan to seal edges. Make meandering streams in clay that lead to water.
3. Cut indoor-outdoor carpet, sponge, or florist's foam to fill the space across the pan along the edge of the clay. This represents a wetland buffer between dry land and open water. This must fit well—the model won't work if there are large spaces under the wetland or between it and the sides of the pan.



Time to complete

Activity 3.1a: 90 minutes if students make models in small group activity; 50 minutes for teacher-led demonstration.
Activity 3.1b: 50 minutes or less.

Mode of instruction

Classroom demonstration or independent group work with classroom discussion.

Materials

1. Photocopy of "Wetlands at Work" and "From Marsh to Marina" worksheets, one for each student. Overhead transparency of "Wetlands at Work."
2. Overhead projector
3. For each model (Activity 3.1a):
   - Modeling clay
   - Long shallow pan: a 13" x 9" baking pan, or a roller paint pan
   - Scraps of indoor/outdoor carpeting, florist's "Oasis" foam, or sponges
   - One-half gallon plastic milk jug w/lid
   - Cup of soil
   - Jar of muddy water

Preparation

Teach this as an alternation between teacher-led discussion and demonstration, or, if students make their own wetlands, as a discussion with activity completed by groups.

Outline

Before class

1. Review background information.
2. Photocopy two worksheets and overhead transparency.
3. If teaching this as a demonstration, make the wetland model.
4. If students are making the model, assemble materials.
5. Make the milk jug sprinkler.
6. If doing extensions, check section for materials to decorate models.

During class

1. Discuss the usefulness of models.
2. Review with students; list characteristics of a wetland on board.
3. Hand out "Wetlands at Work" worksheet.
4. Conduct demonstration or lead students in small group activity.
5. Students complete worksheet, whole class discussion on responses.
6. Pass out "From Marsh to Marina."
7. Students complete worksheet, whole class discussion on results.

3. Fit the piece of carpeting or sponge into the wetland area, and sprinkle some "rain" on the land. **Compare results to prediction.** Students observe and describe what is happening. (*Some of the water is slowed down by the wetland carpeting.*) Excess runoff slowly flows into the body of water. Point out the wetland absorbed some of the water (pick up the wetland and squeeze some water out to prove it).

4. **PREDICT:** What do you think will happen if the wetland is removed? (*The water will not be absorbed; it will flow more quickly into the body of water.*) Remove the carpeting and pour out water. Pour the same amount of water on model at the same spot and rate as before.
Compare results to prediction. Have students note differences. *(The water should fill the body of water much more quickly and may eventually overflow and flood the land that is no longer protected by the wetland. Most wetlands are shallow basins that collect water and slow its rate of flow and retain water for a time. This slowing process reduces flooding and soil erosion.)*
PREDICT: If a wetland is filled in and houses are built on the fill, what might happen to the houses during a severe rainstorm? Why? (*They might be flooded because the wetland will not be there to absorb and slow the rush of water from higher ground.*)

5. Pour the water from the last demonstration out of the model, squeeze out and replace the piece of carpeting. Explain this demonstration will be just like the first, except soil will cover the clay.
PREDICT: What do you think will happen to the bare soil when it rains? (*The rain should pick up and carry some, but not all, of the sediment over the land and into the body of water, representing topsoil erosion.)*

6. Spread soil over the clay and make it rain, or pour muddy water from jar onto the land. This water represents polluted runoff and sediment from the watershed.
Compare results with prediction. Compare the water that ends up in the body of water with the water in the jar. What do you think happened? Discuss results. *(Soil particles trapped by carpeting, which made water in catch basin much clearer than the muddy water in the jar. The "uphill" side of the wetland should be coated with trapped sediment.)*

7. Remove carpeting, pour out basin, and try experiment again. What happens without the wetland in place? Ask: Why did all the dirt particles end up in the body of water this time? (*The thick mat of plant roots traps silt and filters out pollutants as the carpet or sponge did in the model. Silt and pollutants end up in lakes, rivers, and other waters.*)

3.1.a. Results and reflection

Students write their answers on the "Wetlands at Work" worksheet.
1. What happens where there is no wetland? (*Silt and pollution rushes into the body of water.*)
2. How might muddy water affect fish? (*It is harder for them to see and breathe with clogged gills, could lead to their death.*)
3. How might the muddy water affect other animals and plants? (*Settling sediment smothers bottom dwelling animals who filter feed, blocks sunlight*

needed for plant growth, lowers visibility of animals who fish, introduces toxins and eliminates food sources, disrupts food chain)

4. How might all of this affect students' lives? (*Decrease in natural resources and food sources; decline in quality of drinking water [freshwater wetlands only]; impacts on recreation such as swimming and fishing; change in how things look; changes in economy from fewer harvestable species.*)

Activity 3.1b
From Marsh to Marina

Salt marshes can be great places to make a living! Native Americans living along the coasts knew this—so did the earliest European settlers. This activity gets students to think about how people have used (and abused) salt marshes over the years.

(From Marsh to Marina was adapted from *NatureScope: Wading into Wetlands*, National Wildlife Federation. Learning Triangle Press, 1997. Reproduced with permission of The McGraw-Hill Companies.)

1. Pass out "From Marsh to Marina" worksheet and a blank piece of paper. Explain that the pictures represent ways people used salt marshes through time. You may want to let the students color the pictures. Have students cut out the pictures and try to arrange them in order, from top to bottom, from past to present.

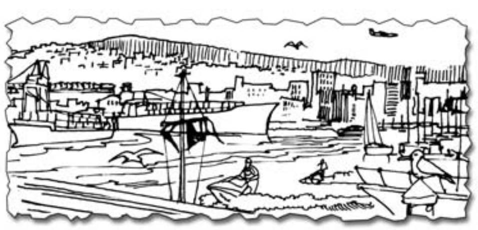
2. When everyone has finished, go over the answers. Students glue pictures in correct order, and label the time period of each picture:

Picture 1: 1600	Picture 4: 1950
Picture 2: 1700	Picture 5: 2000
Picture 3: 1850	

3. Use the following information to talk about each picture:

Picture 1. Native Americans were the first people to use the resources of California's salt marshes. In the West, the Miwok, Chumash, and Ohlone tribes depended on the salt marshes along the Pacific Coast. The Native Americans found game in salt marshes—especially in the fall, when huge flocks of ducks and geese migrated through. Native Americans gathered oysters, clams, and other shellfish in the tidal creeks of salt marshes; built special fish traps out of brush; and scooped trapped fish into buckets.

Pictures 2. Many Europeans settled near salt marshes during the 1700s and 1800s. Living near the marsh wasn't an easy life. Europeans were unaccustomed to the mosquitos and other biting insects. Cattle would occasionally have to be destroyed when they sank too far down into the marsh mud to be rescued. But there were advantages to marsh living, too. There was plenty of food, and the vast fields of salt marsh hay made good grazing grounds.



Picture 3. By the late 1800s, many salt marshes in North America were settled. People began to have a big impact on the ecology of the land. Have the students compare this situation with that depicted in Pictures 1 and 2. When there were few people, the marsh could easily recover from their impacts, but with more people, the damage is more serious and long-lasting. Students may name the ways they see that the people are affecting the marsh.

Pictures 4 and 5. By the 1950s, people had drastically changed many original salt marshes. Few people recognized the marshes' importance in their natural state. To turn them into "useful" places, they filled them in and built airports, houses, and buildings. Students may determine how the wildlife in Picture 1 and Picture 5 differ (*fewer species in picture 5; shorebirds, deer, and other salt marsh animals gone; few places for birds*).

Results and Reflections

Students describe what could happen to water, sediments, homes, and wildlife when wetlands are destroyed. This can be accomplished either by writing a simple paragraph, or creating an illustration of a wetland that has been filled, drained, or paved over, and subsequent effects on plants, animals, and humans.

Conclusions

Wetlands are important parts of the watershed and the natural landscape. They provide beneficial services such as filtering sediment out of water, and slowing down the rate at which the water enters larger bodies of water, as well as providing habitat for many native species. Wetlands have been used for many purposes throughout history, but are now vanishing. Without wetlands, plants and animals that depend on this unique environment will disappear.

Extensions and applications

1. Have students landscape the models with plants and animals attached with toothpicks. Use an assortment of materials. Some ideas:
- Cotton swabs for cat tails. Paint sticks green and cotton brown, or paint toothpicks green and stick bits of brown clay to the tops.
- Long pine needles for reeds. Make trees by gluing pieces of green sponge onto twigs. Dried flower heads make nice trees.
- Photocopy, cut, and color wetland creatures from page 19 and glue them onto toothpicks.

2. Almost all of California's wetlands have been filled. Only 10 percent remain. Demonstrate with 10 blocks: take 9 away, what is left represents how many wetlands remain. Only 1/10 remain. What fraction has been filled?" i.e. $10/10 - 1/10 = ?$
3. Students may identify a wetland in the local area (see Appendix B) and relate information to their community.
4. Have students write a paragraph, containing a topic sentence and at least three supporting sentences, to describe their experience if they were a wetland plant. What would they see, hear, smell and feel?
5. Have students read a book about a wetland plant or animal (such as an egret, pickleweed, or leopard shark) and complete a book report.

ANSWER KEY
1-C, 2-A, 3-E, 4-B, 5-D

Adapted from

Wetland in a Pan, from *WOW! The Wonders of Wetlands* is used with permission from Environmental Concern Inc. For further information contact Environmental Concern Inc. at (410) 745-9620 or visit *www.wetland.org*

From Marsh to Marina, from *NatureScope: Wading into Wetlands*, National Wildlife Federation. Learning Triangle Press, 1997. Reproduced with permission of The McGraw-Hill Companies.

Wetlands at Work

Answer these questions after your teacher has shown the wetland model.

1. What happens where there is no wetland?

____

____

2. Can fish live in muddy water or water with pollution in it? Can they see, or breathe?

____

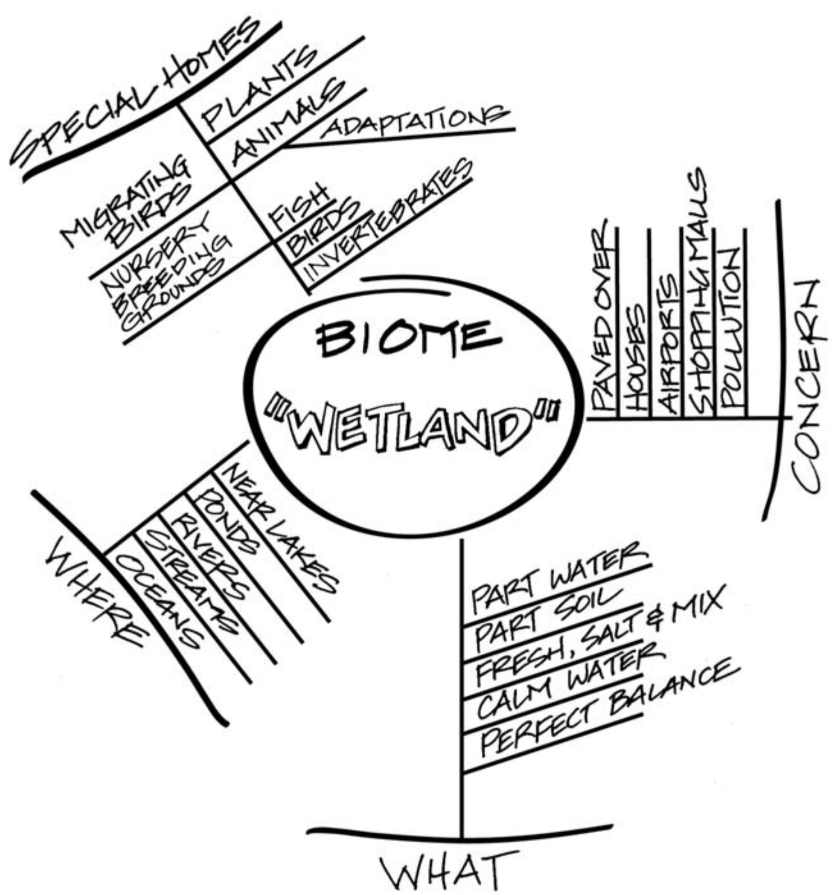
____

3. Can other plants and animals live in the muddy or polluted water?

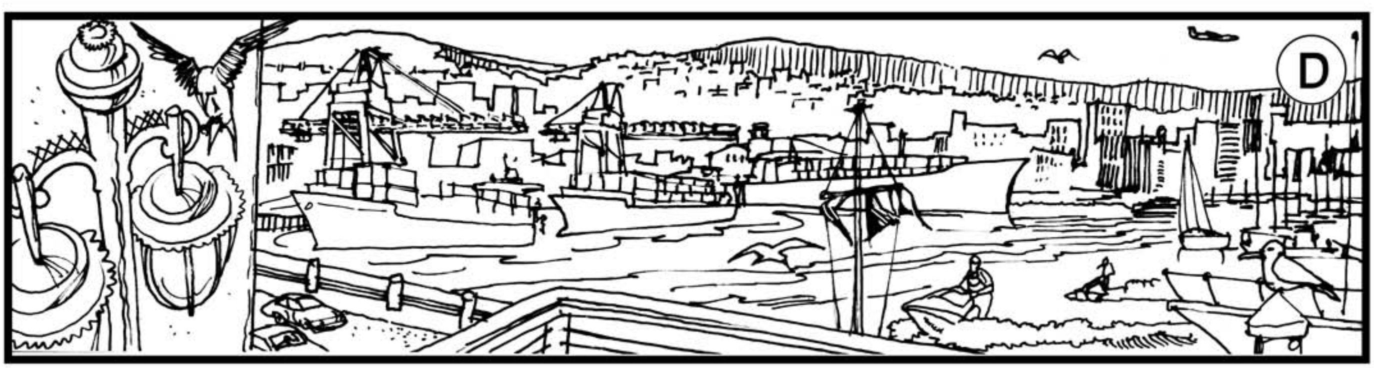
____

____

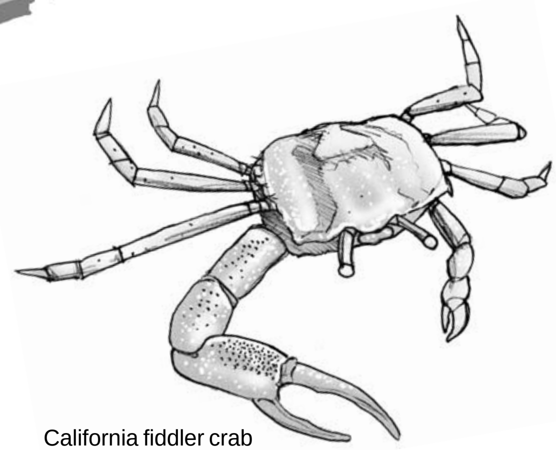
4. Here are words that tell why wetlands are special. Draw a picture of a special wetland.



From Marsh to Marina



Grade 3 Activity



California fiddler crab
Uca crenulata

Science skills

- Organizing
- Inferring
- Predicting
- Communicating
- Graphing

Concepts

- Plants and animals that live in wetlands have special relationships to each other and to their part-wet part-dry environment.
- Salt marshes are a type of wetland.
- Salt marshes provide habitats for both fresh and salt water species.
- Salt marshes are one of the most productive ecosystems on Earth.
- A food chain is a series of plants and animals that pass matter and energy through the chain by eating one another.
- A food web is one or more overlapping food chains; organisms at one trophic level eat different foods, including other species at their same and lower trophic levels.

Activity 3.2
Marsh Munchers

Are you a predator or the prey in the salt marsh? Students play this game and become part of the food web—they eat and are eaten!

Background

A salt marsh is an important ecosystem found between a land mass and the ocean. Fresh water and salt water come together to form a unique habitat for wildlife. The constantly changing mixture of fresh and salt water provides food and shelter for species from both habitats. Activity 3.1 focused on the physical components; this activity focuses on the living components of the salt marsh ecosystem.

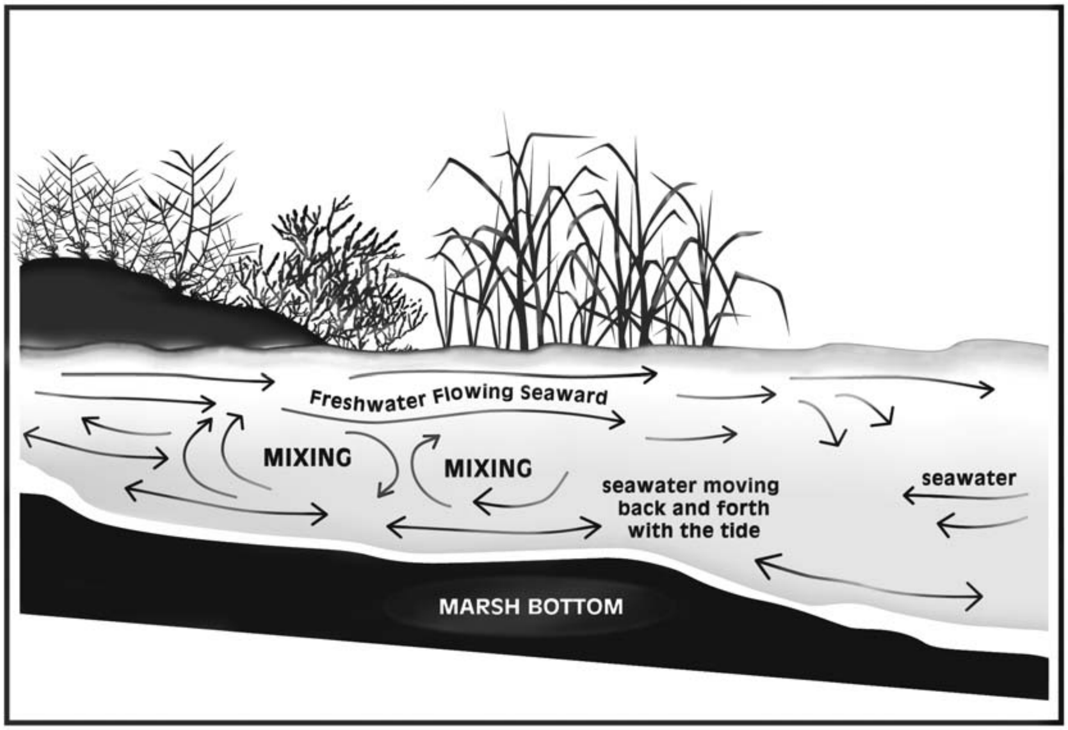
Salt marshes are one of the most productive ecosystems on Earth—they are five times more productive than a field of wheat! The main producer for this ecosystem is salt marsh grass, which grows and thrives in nutrient-rich waters of estuaries where salt water from the ocean mixes with freshwater from land drainage. Salt marsh grass is constantly producing new growth. Bacteria promote the decay of the marsh grass, which in turn produces *detritus*. Detritus is dead and decaying plant or animal matter. Fiddler crabs, snails, small shrimp, and fish feed on decomposed marsh grasses. Oysters and clams filter detritus and tiny living plants from the water, then become food themselves for crabs, birds, and fish. Many marine organisms and commercially valuable fish species, including flounder, salmon, and striped bass, depend at some point in their lives on salt marsh ecosystems.

In Elkhorn Slough, one of California's last remaining large wetlands, college students conduct research to find out just how rich this environment is. They have found some astounding numbers! In a standard coffee can core, the following numbers are typical:

- 100-1000 organisms/core (a big range because organisms are patchy)
- 10-20 species/core

This is just invertebrates: if you included diatoms, bacteria, protozoans, etc. of course the numbers would be **orders of magnitude** higher. The coffee cans are about seven inches in diameter, and cores are taken to a depth of seven inches.

Many resident and migratory birds are dependent on salt marshes for food and nesting. Ospreys, sandpipers, and the heron family feed along marsh creeks during the spring and summer, while ducks and northern harriers can be seen in the winter months. Raccoons, shrews, and mice wander through the marsh in search of food, and deer, grasshoppers, and geese feed on the grasses. Marshes also provide critical services (e.g., trapping sediments and nutrients from runoff so that waters in bays and along the coast are clean and clear), as well as being exciting places to see lots of wildlife such as birds, fish, and invertebrates.



Salt Marsh Mixing

California Science Content Standards

3. Life Sciences

Adaptations in physical structure or behavior may improve an organism's chance for survival. As a basis for understanding this concept:

3.a. Students know plants and animals have structures that serve different functions in growth, survival, and reproduction.

3.b. Students know examples of diverse life forms in different environments, such as oceans, deserts, tundra, forests, grasslands, and wetlands.

3.c. Students know living things cause changes in the environment in which they live: some of these changes are detrimental to the organisms or other organisms, and some are beneficial.

3.d. Students know when the environment changes some plants and animals survive and reproduce; others die or move to new locations.

Activity

This simulation introduces how a salt marsh food web works. First you will discuss what students know about salt marshes. Then you play a game that illustrates how a salt marsh food web works.

1. Lead a classroom discussion about salt marshes. What do you know about salt marshes? Where do we find salt marshes? (*Along coasts or bays, in protected areas where fresh water meets salt water. Salt marshes have special birds and animals that live there, dependent on the part wet, part dry habitat. Salt marshes are very productive. Because of human impacts, there are few salt marshes left in California.*) Draw the above diagram on the board or project on an overhead projector, and discuss the characteristics of a salt marsh. Note how sea water flows in with the tide, and freshwater flows over it, with some mixing in between. Explain that salt marshes are very rich and productive areas for animals and plants to inhabit because of all the nutrients brought to the marsh by creeks and rivers, and because they are shallow and receive lots of sunlight for plants to grow. Salt marsh inhabitants must be able to live in both fresh and salt water. **Ask**: Do you know of any animals that live in a salt marsh? (*Birds, small mammals, fish, and invertebrates such as snails and oysters.*) Discuss the ways in which salt water mixes with fresh water.

2. Discuss the importance of detritus in salt marshes. Salt marshes produce lots of *detritus* (dead or decaying plants and animals). Detritus plays an important part in the salt marsh food web. Producers are the first level in a food web; plants are producers that create food from sunlight. Salt marsh grasses are very abundant and constantly grow and die to become detritus. Bacteria and fungi are decomposers. They break down detritus. Salt marshes produce a lot of food, and plants and animals grow and die to create more detritus. Snails and worms eat detritus,

California Mathematics Content Standards

Number Sense

2.1. Find the sum or difference of two whole numbers between 0 and 10,000. (Extension #1.)

2.4. Solve simple problems involving multiplication of multi-digit numbers by one-digit numbers (3,671 x 3 = __). (Extension #1.)

California English-Language Arts Content Standards

Reading Comprehension

2.7. Follow simple multiple-step written instructions (e.g., how to assemble a product or play a board game.) *Standard achieved if game instructions are distributed to students.*

Objectives

Students will:

- Understand that salt marsh plants and animals are adapted to the special part wet, part dry, and part saltwater, part freshwater environment.
- Describe the difference between a food chain and a food web.
- Describe some of the components of a food web and how it works.
- Identify some of the components of a salt marsh food web.
- Act as predator or prey in simulated salt marsh food web.
- Identify the interconnectedness of plants and animals in the salt marsh food web.

Time to complete

60 minutes

Mode of instruction

Teacher-led whole class discussion, followed by game where students use body movement and pantomime to simulate feeding motions of marsh animals.

and many of the larger animals eat snails and worms. Grasses, detritus, and bacteria aren't big and flashy like hawks and raccoons, but without them, the salt marsh food chain would collapse!

3. Discuss food webs. What do you know about food webs? (*A food web is a way to describe how the living parts of an ecosystem relate. Bigger animals eat smaller animals. There are predators and prey that eat and are eaten. Food webs describe who eats whom.)* Display the "Wetland Food Web" diagram on an overhead projector, or draw it on the classroom board. Plants and animals can be arranged in levels of who eats whom, named "trophic levels." Have students help decide who eats whom in the salt marsh food web. **Discuss**: In any food web, there are producers (mostly plants) and consumers. By growing and being eaten, producers create food for consumers to eat. Food webs also contain predators and prey—predators capture prey for food, and prey are eaten by predators.

Pre-game instructions

1. The class will pretend to be animals in a salt marsh. Each animal plays an important role in the food web. In this game, all animals are consumers. The producers, plants, and bacteria that support the detritus-eaters (prey) are not a part of this game (plants and bacteria do not provide much action in an action-oriented game). *This is a simulation; in real life, these animals play several roles in the food web.*
2. Give one envelope to each student. Explain that their identities are a secret. Each envelope contains the identity and feeding behavior of one animal that lives in a salt marsh. The only way others will know what kind of animal they are is by the way they feed. When students receive their envelopes, explain that some students will be detritus-eaters and others will be predators who eat the detritus-eaters (prey).
3. Have students open their envelopes and see what animal they are and what feeding behavior they use. Students may need help with this stage. Remind them to keep their identities a secret, but help them learn to pantomime their feeding behavior. **Note: if your students may have difficulty with this activity (i.e. predators not being able to recognize prey by feeding behavior), make name tags to hang around students' necks: shrimp, fish, snail, oyster, crab.**
4. Discuss what predators eat. Make this table on the board without the *x*'s. Fill in the table as you discuss who eats whom.

Salt Marsh Food Web: Who's Eating Whom?

	Human	Shore Crab	Raccoon	Green Sturgeon	Egret
Juvenile fish			x	x	x
Shrimp	x	x	x	x	
Snail	x	x			
Oyster	x	x			
Fiddler crab			x		x

5. Explain rules of the game.

a. Each student represents a detritus-eater or a predator.

b. Each detritus-eater has four food tokens, representing five marsh animals of the same species (five snails, five oysters, five fish...).

Materials

1. Timer
2. Construction paper: white, green, yellow, blue, and red
3. Predator cards (master provided)
4. Detritus-eater food tokens (master provided)
5. One envelope per student
6. Overhead transparency of "Wetland Food Web" and "Marsh Mixing" (page 15)
7. Overhead projector

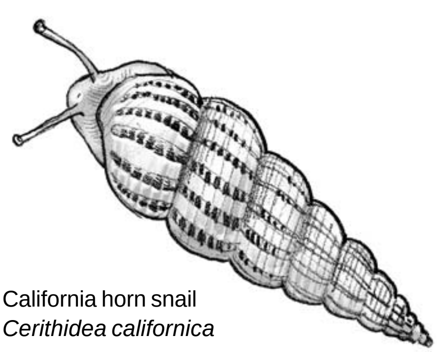
Prepare and Place in Envelopes
(One envelope per student. Envelope includes either predator card or detritus-eater food tokens. Photocopy food tokens onto colored construction paper. Adjust numbers for your classroom.)

Predator Cards (white paper)

1 raccoon	1 each
1 shore crab	1 each
1 green sturgeon	1 each
1 egret	1 each
1 person	1 each

Detritus-Eater Food Tokens
(use colored paper or have students color tokens)

- 5 fiddler crabs: 4 red tokens each (20 total)
- 5 snails: 4 blue tokens each (20 total)
- 5 oysters: 4 yellow tokens each (20 total)
- 5 juvenile fish: 4 green tokens each (20 total)
- 5 shrimps: 4 white tokens each (20 total)



California horn snail
Cerithidea californica

c. Detritus-eaters and predators must pantomime their feeding behavior throughout the activity. Detritus-eaters show their feeding styles from stationary squat positions; predators will walk and display their behavior.
d. Predators tag detritus-eaters by tapping them on the shoulder.
e. The detritus-eater must give a food token to an appropriate predator (see table) when tagged.
f. Each predator must acquire eight food tokens from appropriate prey within the time period to stay alive. The time period represents one tidal cycle (low to high and back to low tide). Terrestrial predators can only feed when the tide goes out, and marine predators can only feed when the tide comes in. Therefore, all predators are limited by a time constraint within which they must acquire enough food.
g. Each predator can only acquire one token from each detritus-eater.
h. Detritus-eaters keep feeding while they still have tokens. When they run out of tokens, they sit quietly in place decomposing in the salt marsh.

Note: Depending upon time constraints, play the game a number of times so students have the opportunity to be both predator and prey.

Playing the game

1. Get settled where the game will be held. All students should have their envelopes with them. **Predict**: Ask students what they think will happen in this game. Will all the predators be able to collect enough food to survive? How will the predators know which prey is appropriate to eat? (*By the behavior of the detritus-eaters—the predators know by experience what they are looking for, what tastes good and is relatively easy to catch. Again, if this is too difficult, make name tags for detritus eaters.*) Will they run out of prey? (*No, in a healthy salt marsh, there are more prey than predators. In an unhealthy habitat, perhaps one into which humans have either developed or dumped polluted water and trash, the food web breaks down, with less food for all.)*
2. Set the boundaries of the game (a circle drawn on the pavement outdoors, a boundary set by stationary objects [from that tree to this fence], or a very large string circle indoors). Tell students there will be a set time limit.
3. Have all the detritus-eaters spread out within the boundaries or the playing field and start pantomiming their feeding behavior. Remind detritus-eaters to be sure to distribute themselves throughout the area, not to clump up in one area. This makes them more difficult to catch.
4. Predators begin to pantomime their feeding behaviors, and you start the timer. Tell predators to capture their prey (tap on shoulder, one token only from each detritus-eater) and place their tokens in their envelope. Call time when appropriate (after *some* predators have acquired eight food tokens—time may vary, but do not allow enough time for all predators to get eight tokens.)
5. Students hold onto their envelopes for discussion.

Results and reflection

1. Back in the classroom, discuss results. Have predators empty their envelopes onto their desks. **Ask**: Did every predator get eight food

Preparation

Choose a location to do the game, a **large** playing area inside or outside. Have rainy day indoor site planned (cafeteria, multi-use room). Designed for 25 students; can be adapted for smaller or larger groups.

Vocabulary

Salt marsh, adapt, prey, predator, producers, consumers, food web, fresh water, salt water, tides, decompose, detritus, food chain, trophic level, ecosystem

Outline

Before class

1. Create transparency of marsh mixing diagram and "Wetland Food Web."
2. Photocopy predator cards onto white construction paper. Cut.
3. Cut 20 detritus-eater food tokens of each color from colored construction paper. *See materials list for instructions.*
4. Photocopy food web and salt marsh mixing diagrams onto overhead transparencies (or draw them on the board).
5. Place colored construction paper food tokens and predator cards into the appropriate envelopes.

During class

1. Ask what students know about salt marshes and food webs. Display "Marsh Mixing" overhead transparency and discuss the fresh water/salt water mixing dynamics and effects on organisms.
2. Discuss the nature of the simulation and what students are modeling.
3. Explain rules of the game. Demonstrate feeding behaviors.
4. Play the game.
5. Discuss results. Did everyone get enough food to survive?
6. Repeat game if students are unclear on the concepts.
7. Return to class and discuss the "Wetland Food Web" overhead transparency.

tokens during the time period? Why, when there is so much food out there, do all animals not get their fill? (*Some, like people, are more mobile and selective about what foods they eat in the marsh because they can get food in other habitats. Others, like shore crabs, green sturgeons, and egrets, are more selective in what they can eat. Only the raccoon eats almost all the detritus-eaters in the salt marsh.*) What happens to all of the detritus-eaters who don't get eaten? (*They die and decompose, creating more detritus for detritus-eaters to eat.*)
2. Fill in the connecting arrows on the "Wetland Food Web" in one of three ways: display on overhead projector, draw it on the board, or have students cut out the animal illustrations to arrange on their desks. Discuss and show the connections between all the animals in the salt marsh food web. Don't forget the detritus—you may illustrate it by little dots sprinkled over the food web by each detritus-eater.
3. What would happen to the salt marsh animals if the salt marsh was filled in with dirt and an airplane runway built on it? Or, if it was dredged and made into a harbor? (*Some of the predators, like people, egrets, and raccoons would leave and find food in other nearby habitats. For some predators, the other habitat would not be as easy for them and they would have to work harder to find the right food. Others dependent on salt marsh conditions, like the fiddler crab, oyster, and juvenile fish, would not survive.)*

Conclusions

Plants and animals that live in a habitat are related to each other by what they eat. Salt marshes are a very rich and productive habitat that support a wide variety of animals that depend upon special conditions to survive, including a part wet, part dry environment, and a daily exchange of fresh water and salt water. It is important to protect remaining salt marshes so plants and animals have a home.

Extensions and applications

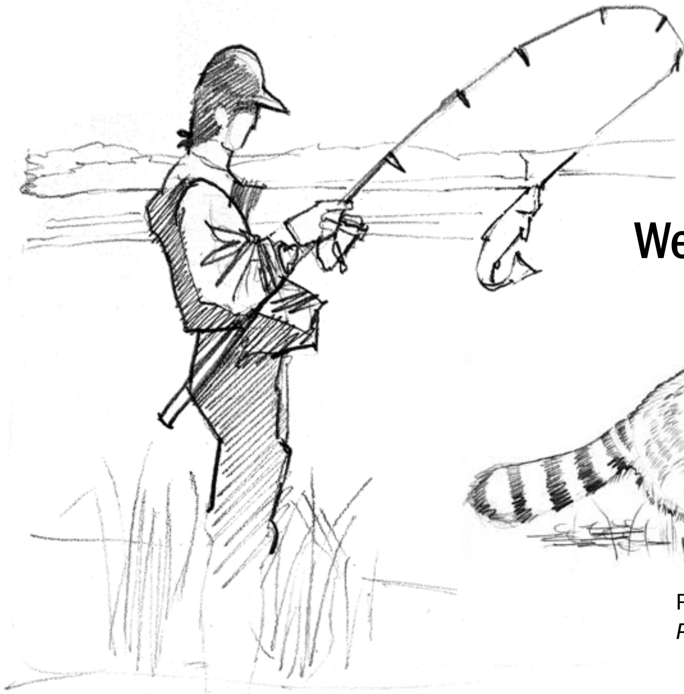
1. Determine how much food was available to predators. Guide students in computing the number of food tokens available by multiplying the number of detritus-eaters by five. Then, as a class, create a bar chart showing how many food tokens each predator collected. What was the total number of tokens collected? How many tokens were left uneaten, to decompose in the marsh?
2. Have students paint a mural of the salt marsh food web, with accurate drawings of each animal. Draw in the grasses and detritus. With yarn, connect each animal with what it eats.
3. Research and locate a salt marsh near to you (see Appendix B). Arrange a field trip to the salt marsh, and locate some of the plants, animals, and birds in the salt marsh food web.

Adapted from

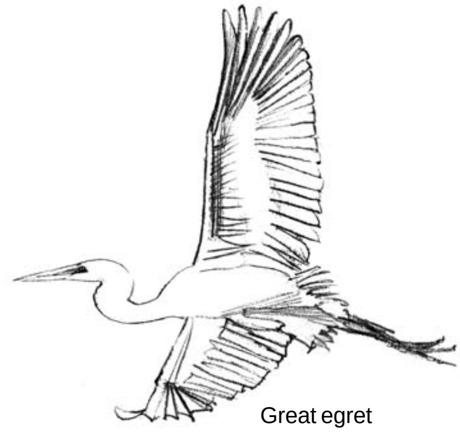
Additional References

Appendix B. Wetlands of California
ceres.ca.gov/wetlands/geo_info/so_cal/so_cal_wetland_index.html
eureka.regis.berkeley.edu/ncccwis/

Wetland Food Web

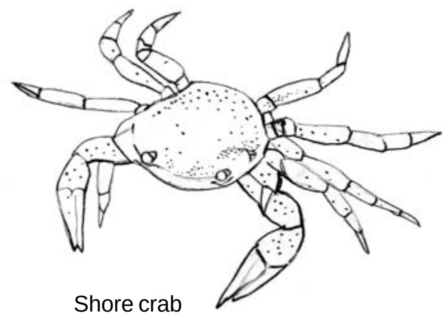


Human
Homo sapiens sapiens

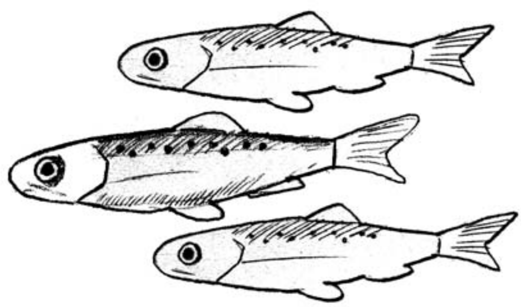


Great egret
Casmerodius albus

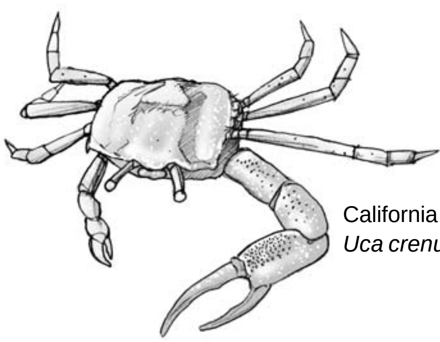
Raccoon
Procyon lotor



Shore crab
Pachygrapsus crassipes



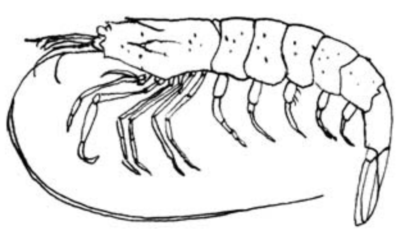
Juvenile fish
Oncorhynchus spp



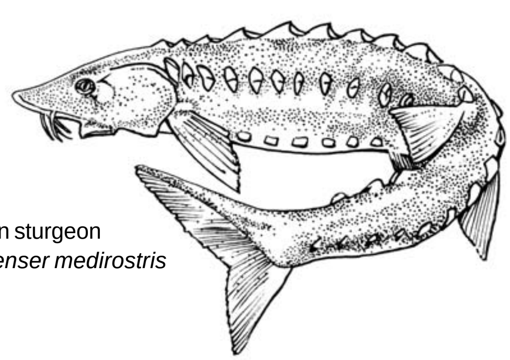
California fiddler crab
Uca crenulata

California horn snail
Cerithidea californica

Pacific oyster
Crassastrea gigas



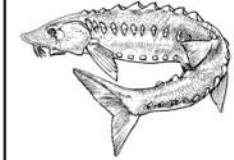
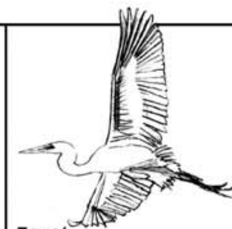
Bay shrimp
Crangon franciscorum



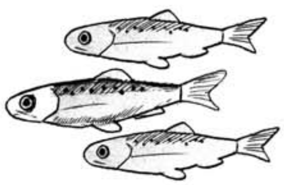
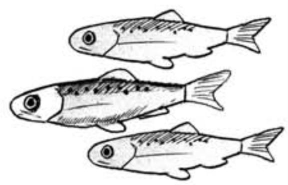
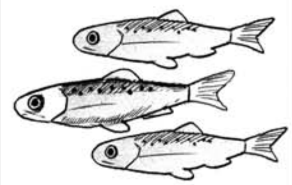
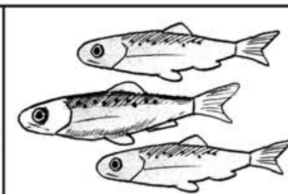
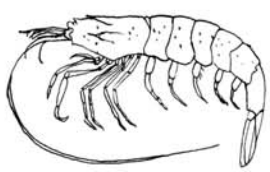
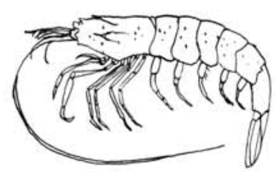
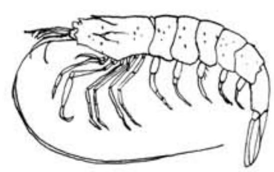
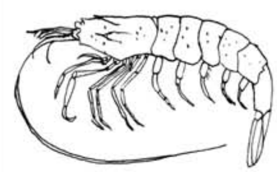
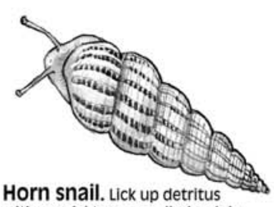
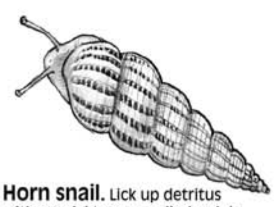
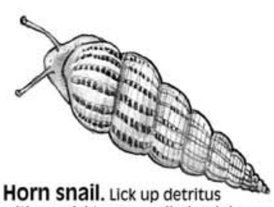
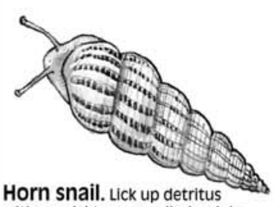
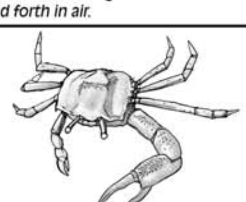
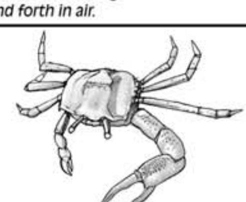
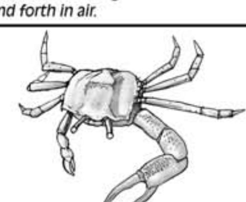
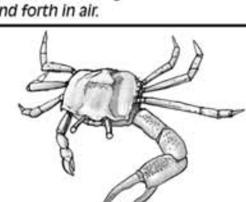
Green sturgeon
Acipenser medirostris

Master for Marsh Munchers

Predator Cards

 **Person fishing.** Walk forward holding fishing pole and casting line. *Tag prey by touching shoulder.*	 **Shore crab.** Walk sideways, waving arms like claws. *Tag prey by touching shoulder.*	 **Raccoon.** Walk forward washing hands. *Tag prey by touching shoulder.*	 **Green sturgeon.** Walk with hands held forward and together, like a mouth. *Tag prey by touching shoulder.*	 **Egret.** Strut with hands on hips, elbows like wings. *Tag prey by touching shoulder.*

Detritus-Eater Food Tokens

 **Juvenile fish.** Gulp down detritus in water or on bottom. *Pucker lips and make sucking noises while feeding.*	 **Juvenile fish.** Gulp down detritus in water or on bottom. *Pucker lips and make sucking noises while feeding.*	 **Juvenile fish.** Gulp down detritus in water or on bottom. *Pucker lips and make sucking noises while feeding.*	 **Juvenile fish.** Gulp down detritus in water or on bottom. *Pucker lips and make sucking noises while feeding.*
 **Bay shrimp.** Stir up mud and detritus with legs, lift particles to mouth. *Make stirring motions with arms.*	 **Bay shrimp.** Stir up mud and detritus with legs, lift particles to mouth. *Make stirring motions with arms.*	 **Bay shrimp.** Stir up mud and detritus with legs, lift particles to mouth. *Make stirring motions with arms.*	 **Bay shrimp.** Stir up mud and detritus with legs, lift particles to mouth. *Make stirring motions with arms.*
 **Horn snail.** Lick up detritus with special tongue called radula. *Make licking motion with one hand as radula near mouth.*	 **Horn snail.** Lick up detritus with special tongue called radula. *Make licking motion with one hand as radula near mouth.*	 **Horn snail.** Lick up detritus with special tongue called radula. *Make licking motion with one hand as radula near mouth.*	 **Horn snail.** Lick up detritus with special tongue called radula. *Make licking motion with one hand as radula near mouth.*
 **Pacific oyster.** Filter detritus from water with gills. *Wave arms back and forth in air.*	 **Pacific oyster.** Filter detritus from water with gills. *Wave arms back and forth in air.*	 **Pacific oyster.** Filter detritus from water with gills. *Wave arms back and forth in air.*	 **Pacific oyster.** Filter detritus from water with gills. *Wave arms back and forth in air.*
 **Fiddler Crab.** Pick detritus from sand with one or two claws. *Pick object from ground with thumb and first finger acting as claw.*	 **Fiddler Crab.** Pick detritus from sand with one or two claws. *Pick object from ground with thumb and first finger acting as claw.*	 **Fiddler Crab.** Pick detritus from sand with one or two claws. *Pick object from ground with thumb and first finger acting as claw.*	 **Fiddler Crab.** Pick detritus from sand with one or two claws. *Pick object from ground with thumb and first finger acting as claw.*

Activity 3.3
The Perfect Beak

Find the beak to match the food! Students learn how birds' beaks and tongues are adapted to best take advantage of their favorite food.

Science skills

- Observing
- Predicting
- Experimenting
- Gathering and analyzing information
- Graphing data

Concepts

- Habitats provide food for animals.
- Over many years plants and animals establish a balance in their habitat.
- Plants and animals have adaptations that improve their survival in their natural habitat.
- Adaptations affect the way animals look, where they live, and how and what they eat.
- When the environment changes, habitats are altered so they no longer can support the plants and animals that depend upon them.
- To protect and preserve California's native species, their habitats must be kept intact.

Background

It would be impossible for a hummingbird to gobble up a mouse, or for a hawk to slurp up some nectar from a flower. Each type of bird has a special beak and tongue adapted to eating certain foods. Birds use their beaks as tools to collect and prepare food for eating. Students will find out which beaks are best for tearing, scooping, cracking, and picking, and they will try to find out which tools go with which types of "food." Discuss with students different bird beaks and how beaks help birds survive:

Hummingbirds have long hollow beaks they use to probe flowers for nectar. The beak protects the tongue that slurps up the nectar. The tongue is so long, it is curled up inside the beak, and uncurls out to feed.

Curlews, godwits, kiwis, and American avocets, which are shore birds, have long, strong beaks they use to probe for worms, crustaceans, and other small creatures in mud, sand, and water.

Cardinals, sparrows, jays, and finches have very short, conical beaks that are very strong and can break open tough seeds.

Brown pelicans and spoonbills have long, flattened or pouchlike beaks that they use to scoop up fish and other aquatic creatures.

Eurasian wigeons and some ducks have bills that act like strainers to filter tiny plants and animals from the water.

Warblers and flycatchers have small, sharp, pointed beaks for picking insects from leaves, logs, and twigs.

Activity

(The Perfect Beak was adapted from: Fill the Bill, from *NatureScope: Birds, Birds, Birds,* National Wildlife Federation. Learning Triangle Press, 1999. Reproduced with permission of The McGraw-Hill Companies.)

Setting up activity stations

1. Set up six different stations, each with a special type of "food" that fits one of the six different types of beaks. At each station there are three different tools—<u>one that fits the food at the station, and two that don't fit.</u> Make a standup sign for each station (fold 8 ½" x 11" paper into a tent) that tells what type of food is represented. For example, have a sign that says "nectar in a flower" at Station #1. (*The "*" below identifies the tool that best fits the food at the station.*)

Station #1: Water in thin vase for nectar in a flower. (hummingbirds)

Tools: eyedropper or straw*
envelope or small fishnet
large scoop or slotted spoon

Station #2: Large saucepan filled with dry oatmeal, with grapes on the bottom to represent worms buried in the mud or use fake rubber worms instead of grapes. (curlews, godwits, kiwis, and avocets)

Tools: chopsticks*
nutcracker or pliers
strainer

California Science Content Standards

3. Life Sciences

Adaptations in physical structure or behavior may improve an organism's chance for survival. As a basis for understanding this concept:

3.a. Students know plants and animals have structures that serve different functions in growth, survival, and reproduction.

3.d. Students know when the environment changes some plants and animals survive and reproduce; others die or move to new locations.

Objectives

Students will:

- Link adaptation to feeding and survival in birds.
- Describe why there is such variety in bird beaks.
- Identify why birds are dependent on specific foods and habitats.
- Understand the connection between individual species and their habitat.

Time to complete

50-60 minutes

Mode of instruction

Hands-on small group activity

Materials

1. "The Perfect Beak" worksheet
2. Two eyedroppers or straws (if using straws, collect 2 straws per student; students should not share straws)
3. Three pairs of chopsticks
4. Three nutcrackers or pliers
5. Two large scoops or slotted spoons
6. Two strainers
7. Two heavy envelopes or small fishnets
8. Two forceps or tweezers
9. Two tongs
10. Small log or thick, short stick
11. Raw rice and puffed rice
12. Two aquariums or large containers, bowls will do
13. Grapes or fake worms
14. Dry oatmeal
15. Tall, thin vase
16. Large saucepan
17. Walnuts or other nuts in shell (4-6)
18. Styrofoam chunks

Station #3: Whole walnuts or other nuts to represent seeds with hard coverings. (sparrows, cardinals, jays, and finches)

Tools: nutcracker or pliers*
tongs
chopsticks

Station #4: Styrofoam chunks floating in an aquarium filled with water to represent fish and other aquatic animals. (spoonbills and brown pelicans)

Tools: large scoop or slotted spoon*
eyedropper or straws
chopsticks

Station #5: Puffed rice in an aquarium filled with water to represent tiny aquatic plants and animals. (Eurasian wigeons and some other ducks)

Tools: strainer*
forceps or tweezers
tongs

Station #6: Rice spread on a log to represent caterpillars and other insects. (warblers)

Tools: forceps or tweezers*
envelope or small fishnet
nutcracker or pliers

Activity Stations

1. **Ask:** What do you know about beaks? What are they used for? Are they all the same? Why would birds have so many different shapes of beaks? From ducks to pelicans, here they will learn about adaptations, how plants and animals change over time to survive in their habitat.
2. Explain that the students will go to each activity station as a small group. There will be three different tools at each station, each of which represents a different type of bird beak function. They must decide which "beak" (tool) would most efficiently get the food at each station. Students decide by trying out different tools. They can discuss their results with others in their group, but will record their own choices on "The Perfect Beak" worksheet. <u>Tell students to pick up the food with a tool, but not to eat it!</u> Set a time limit for how long students stay at each station. Students must leave the station as they found it (allow time for cleaning up).
3. Hand out a copy of the "The Perfect Beak" worksheet to each student and explain how to complete it. At each station, they will take turns trying the tools with the food. Once they choose the best tool, they write the name of the tool on their worksheet. On the worksheet are pictures of different birds and their beaks. On the line under each picture, they write the number of the station that represents the correct beak. For example, they write "1" for hummingbird, as the nectar at station 1 is the hummer's food.
4. Divide the class into six teams; start each team at a different station.
5. After teams have rotated through all stations, they return to their desks for a group discussion. **Ask**: Why do you think birds have so many types of beaks? (*Birds are adapted to their habitats, and in each habitat there is only a certain type and amount of food available. Birds have adapted to feeding*

Preparation

Begin collecting materials one week before class. Lead a whole group discussion on beak types as introduction to activity. Have students complete worksheets as they rotate through the stations. Follow activity with whole group discussion, create a table that compares results, and discuss long-term implications of impacts on habitats.

Outline

Before class:

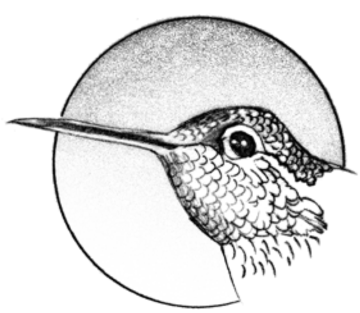
1. Assemble materials the week before the activity day. Have students sign up to bring in materials. Put a large list on the wall, and check off materials as students bring them.
2. Make one copy per student of "The Perfect Beak" worksheet.
3. Day of class: Before students arrive, set up stations with signs and materials.

During class:

1. Lead general group discussion about characteristics of birds (where they live, what they eat, what they look like).
2. Discuss how to fill out the worksheet. Complete small group activity: rotate through activity stations with worksheets. Students record observations.
3. Reassemble as whole group. Create a table on the board and compare results of worksheets. Lead a group discussion on: beak adaptations in general, pros and cons of specialized beak adaptations, and dependence of birds on specific foods.

Answer Key

Station 1: Anna's hummingbird
Station 2: Long-billed curlew
Station 3: Cardinal
Station 4: Brown pelican
Station 5: Eurasian wigeon
Station 6: Hermit warbler



Anna's hummingbird
Calypte anna

in their habitat efficiently to survive.) **Ask**: How can specialized beaks help some birds stay alive? (*A bird with a specialized beak can often eat a type of food that no other bird can eat, such as a hummingbird able to get nectar at the base of a long, narrow flower, or the jay's very sharp, hard beak that can crack nuts.*) **Ask**: How might a specialized beak hurt a bird? (*If a bird's habitat changes and its food is no longer available, the bird might die because it can't eat anything else. Some birds, such as crows and gulls, have versatile beaks. Crows can eat fruits, nuts, berries, dead animals, and even fish and small rodents. This is one reason why crows are found in many habitats.)*

Results and reflection

1. Students fill out worksheet.
2. Students answer this question on the back of their worksheets or in their journals: "If I were a bird, I would have a __________ beak and I would eat _______________. I would live___________."
3. Make a data table on the board and discuss the student's worksheet answers (bird names across top, type of food down the side). **Or,** have students make the data tables themselves on the other side of their worksheets. Did everyone come to the same conclusions? Were there some foods that could be eaten by more than one bird beak?
4. Students explain what would happen to their bird if its habitat changed. Students choose the reason for the change (natural or human-created), and write their answers on back of the worksheet.

Conclusions

All living things have adapted over time to live in their natural habitat. Plants and animals have evolved together to meet survival needs of their species. Adaptations enable them to survive in specific habitats. Bird beaks are one example of how an animal has become adapted to a specific condition of a habitat: it is dependent upon the foods of that habitat. Some birds have very narrow food requirements; some can only eat nectar, others only eat hard-shelled nuts. When habitats are changed and birds' preferred food is no longer available, species dependent on that habitat may not survive.

Extensions and applications

1. Conduct research into other examples of adaptations in California's plant and animal communities.
2. Discuss other types of adaptations in birds. (*Long legs for wading, big wings for gliding, sharp eyes for seeing small rodents, bird songs for mating, feathers for lightness and warmth, bright colors for mating and camouflage.*) Hand out worksheet "Divers and Dabblers" and have students draw the two body types and describe how their adaptations assist them in obtaining food.

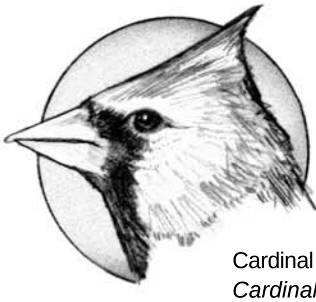
Adapted from

Fill the Bill, from *NatureScope: Birds, Birds, Birds*, National Wildlife Federation. Learning Triangle Press, 1999. Reproduced with permission of The McGraw-Hill Companies.

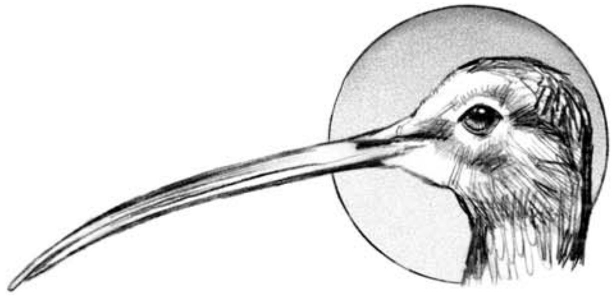
Additional References

Schoenherr, A.A., 1995. *A Natural History of California.* University of California Press, Berkeley.

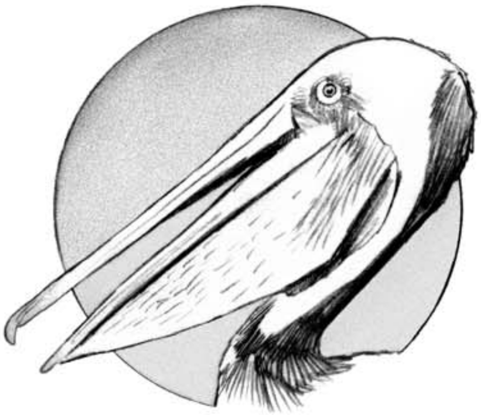
The Perfect Beak



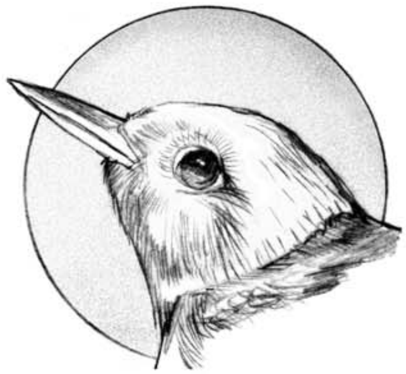
Cardinal
Cardinalis cardinalis



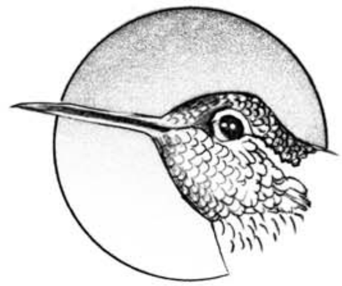
Long-billed curlew
Numenius americanus



Brown pelican
Pelicanus occidentalis



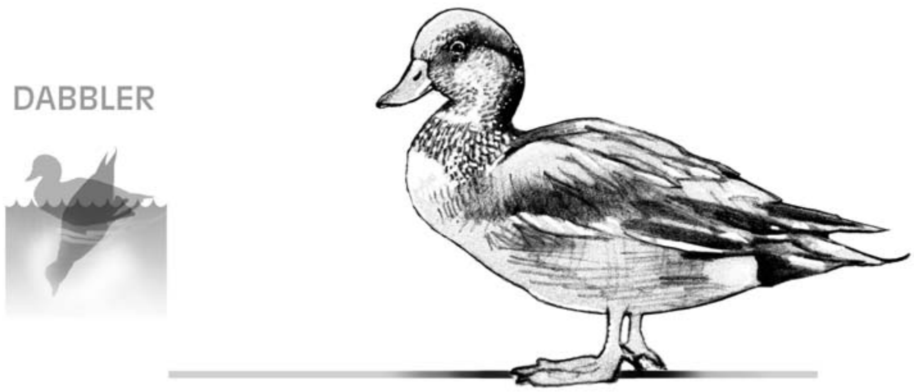
Hermit warbler
Dendroica occidentalis



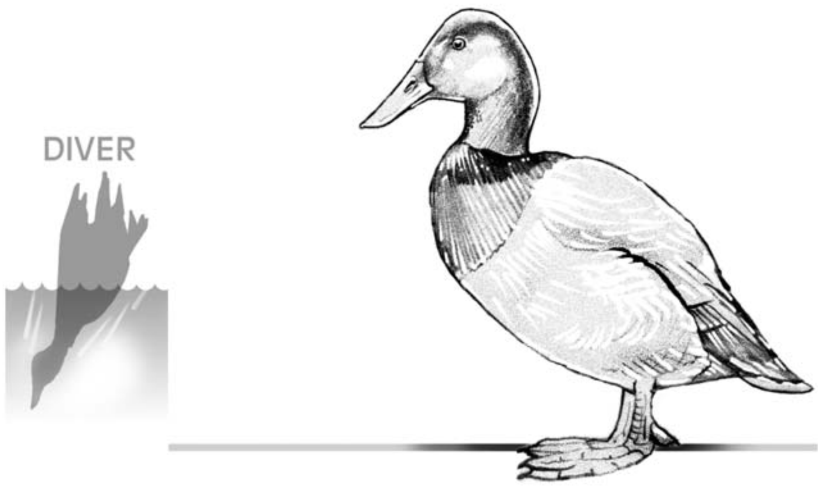
Anna's hummingbird
Calypte anna

Eurasian wigeon
Anas penelope

Station	Best Tool
1	
2	
3	
4	
5	
6	



American wigeon
Anas americana



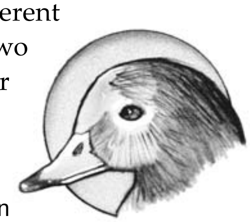
Canvasback
Aythya valisineria

Divers and Dabblers

Beaks are pretty specialized, but they aren't the only bird body part where we can see adaptations working. Body type and flying habits are a few more ways that birds have adapted to their habitat. Let's look at ducks.

There are two basic kinds of ducks: dabblers and divers. Dabblers consume algae, detritus, and snails. Most dabblers feed by inflating air sacs and tipping tail-up to reach the bottom, and some walk out on the mud. Divers spend most of their time on the water, diving to feed on fishes, crustaceans and aquatic larvae. Divers are good swimmers but awkward on land. Dabblers differ from diving ducks in their ability to become airborne; they can spring directly into the air. Diving ducks have to run along the surface of the water to reach sufficient speed to fly.

How is a diver's body adapted to what and how it feeds, and how is this different from a dabbler? Draw the two birds and describe how their body types help them get their food.



Eurasian wigeon
Anas penelope

Notes

Chapter 4
Moving Mountains, Shifting Sands

Earth's surface is constantly changing, and has been since the begining of time. Most changes occur slowly and are hard to observe, such as sea level rise, moving sand dunes, or changes in the amount of sand on riverbanks and beaches. Other changes occur quickly such as landslides, earthquakes, floods, and tsunamis. Most natural changes occur during extreme events when powerful forces such as large waves pound the coast, but some changes are related to human actions. Some important human changes occur inland, often at a great distance from the ocean—such as the damming of rivers. Inland changes can directly affect coastal erosion, beach sand, and life in the ocean's intertidal habitats.

Elements that shape the land are:

- Precipitation: provides the water that transports sediment off the continent. The water in rivers and streams carries sand to make beaches and carves deep gullies through steep rock canyons.
- Gravity: drives (provides the energy for) the flow in streams, and generates large volumes of material for the streams to carry off the land.
- Wind: erodes rock and soil surfaces and transports material. Wind powers ocean waves and currents that shape the coast.
- Tectonics: the forces that move plates, cause volcanic eruptions and earthquakes, elevate the continental land masses thereby providing the potential energy for gravity to act on water, rocks and soil. Tectonics push rocks up, and gravity and water wear them down.

New words

sea level rise; gravity; coastal erosion; rock weathering; sediment; deposit; tectonics

Sand on our beaches comes from rocks that make up Earth's continental crust. Water, wind, chemicals, and temperature changes break down (*weather*) these rocks to coarse gravel and then individual mineral grains. Quartz grains, abundant in these rocks, resist chemical and physical breakdown, and as a result California's beach sands are dominated by quartz grains. Every grain of sand starts as a piece of a bigger rock close to or far away from the beach where it ends up. Rivers and streams carry sand to the ocean; the sand is constantly in motion. Though rivers and streams come from many miles inland they have a big influence on our coast.

California Coastal Commission Area of Critical Concern: Coastal Processes

Relevant California Science Content Standards, Grade 4: Earth Sciences 4. a,b; 5. a, c

Sandy beaches protect the backshore areas and sea cliffs from wave erosion. Ocean waves must first remove or erode the beach before they can attack the cliff. So, the more beach sand there is and the wider a beach is, the less wave erosion of the cliffs. Remove the beach or reduce its width or size, and the cliffs can erode more quickly.

Grade 4 Activities

In these hands-on, interactive activities, students learn about how beaches and coastal cliffs are formed, how flowing water reshapes the land by removing material from one place and depositing it in another, and about coastal erosion.

Activity Goals

Activity 4.1. Moving Mountains to the Sea

Students will:

1. Identify sand and rocks to describe where beach sand comes from and how it is transported to the beach.
2. Know that flowing water, wind, and waves cause erosion, which is the gradual wearing away of objects.
3. Describe how sand is transported great distances by streams, rivers, and longshore currents.
4. Understand how humans have changed natural processes of beach formation and cliff erosion.

Activity 4.2. No Ordinary Sandy Beach

Students will:

1. Develop the skill of close observation.
2. Describe where sand comes from, and how it becomes beach sand.
3. Understand the processes of rock weathering, transport, and deposition.
4. Investigate sand samples to identify their properties and collect clues to their origins.

Activity 4.3. Beach in a Pan

Students will:

1. Create a model of a beach and conduct experiments on the effect of waves.
2. Design an experiment to test the effect of winter storms, coastal development, the construction of a breakwater or jetty, presence of a submarine canyon, or damming of a river.
3. Discover the natural and human impacts on beach formation.

Beaches can be changed when dams are built on rivers. Dams and other flood control structures on rivers and streams trap the sediment (sand, gravel, etc.) that would otherwise be washed into the ocean. The sediment that normally is carried to the ocean and becomes the beach accumulates behind dams on the bottoms of reservoirs, resulting in less sand on the beaches. Less sand on the beaches can result in more erosion of the sea cliffs. Another human activity that may increase sea cliff erosion is construction of buildings, roads, or storm drains on eroding cliffs, causing increased runoff down the cliff face.

Natural forces such as waves also influence the shapes of our beaches and cliffs. Sea cliffs clearly show the erosion potential of waves. Cliffs are formed naturally by the action of waves striking the coastline, an action that breaks down and removes rock from the cliff face. This erosion keeps the cliff face steep and results in a slow landward retreat of that cliff. The presence of a steep sea cliff, by itself, is testimony to erosion at its base by storm waves. The broken down rock fragments created by the wave erosion may become part of the beach. Some sea cliffs, such as those of the Big Sur Coast, are composed of harder rock such as granite and do not erode as easily.

These activities introduce students to the processes of beach formation and the natural and human influenced changes that happen to sandy beaches along our coast.

Grade 4 Activity

Science skills

- Observing
- Gathering and analyzing information
- Predicting
- Experimenting
- Communicating

Concepts

- Rocks on the continent are weathered by water, wind, and chemicals, breaking them into smaller pieces.
- These smaller pieces are transported by rivers and streams to the ocean and become pebble or sand beaches.
- Gravity is an important part of the process of transportation; the rocks, gravel, and sand are carried by the water down slope.
- Waves and currents move sand onto the beach and just offshore, forming beaches that change with seasons.

California Science Content Standards

Earth Sciences

5. Waves, wind, water and ice shape and reshape Earth's land surface. As a basis for understanding this concept, students will know:

5.a. Some changes in the earth are due to slow processes, such as erosion, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

5.c. Moving water erodes landforms, reshaping the land by taking it away from some places and depositing it as pebbles, sand, silt, and mud in other places (weathering, transport, and deposition).

Activity 4.1
Moving Mountains to the Sea

What is sand? Where do beaches come from, and where do they go? Here today, gone tomorrow, you'll never take beaches for granted again.

Background

California's sandy beaches attract millions of visitors each year, and also serve important functions such as buffering cliffs from waves. Without its wide sandy beaches, California would look very different. What is sand made of, and from where does all of our sand come?

In general, sand comes from weathering of continental granitic and sedimentary rocks (the most common sources), weathering of oceanic volcanic rocks (basalts), and skeletal remains and shells of organisms (carbonates). The sand on our beaches is made up of the rocks and soil of California. These rocks and soils *weather* (break down by chemical or physical action), primarily by the chemical and physical action of water. Broken up rock fragments (boulders, cobbles, gravel, sand, silt, and clay) are carried off the continent by water flowing in rivers and streams. The coarser grains are *deposited* (set down) in the ocean at the mouths of the rivers, where the ocean waves and currents take up where the rivers left off. Waves pick up the coarser *sediment* (formed by the broken-up rock fragments) and move it along the coastline. The finer grains, silt and clay, are carried offshore and moved great distances by currents before they settle to the sea floor.

This activity is divided into two sections; *The Layered Jar* is a hands-on activity that shows how rocks, gravel, and sand separate out into layers in water; and *Sandy's Journey to the Sea* is a reading/writing activity that follows the science concepts learned in the hands-on activity.

California English-Language Arts Content Standards

1.1. Read narrative and expository text aloud with grade-appropriate fluency and accuracy and with appropriate pacing, intonation, and expression. *(Applies to 4.1b if story is read aloud by students.)*

California History-Social Science Content Standards

4.1.4. Identify the locations of the Pacific Ocean, rivers, valleys, and mountain passes and explain their effects on the growth of towns.

Objectives

- Students will be able to describe where beach sand comes from and how it is transported to the beach.
- Students will know that flowing water, wind, and waves cause erosion, the gradual wearing away of objects.
- Students will describe how wind, waves, and currents transport sand great distances.

Time to complete

1 hour 15 minutes

Mode of instruction

Students create a layered jar for small group observation and discussion. They then read a story about a rock and its travels to the sea, followed by a whole class discussion. Students write travelogue letters or draw a picture postcard story about the rock's travels.

Materials

Layered Jar activity

One jar for each group of 4-6 students; students share rock and sand:

1. One-half quart or similar size clear, heavy glass jar with tight lid
2. One gallon bucket of pebbles (1/2 to 1 inch diameter)
3. One gallon bucket of gravel (1/4 to 1/2 inch diameter)
4. One gallon bucket of coarse sand
5. One gallon bucket of garden soil
6. Scooper (plastic scoopers from liquid laundry detergent work)

Reading activity

1. Photocopy of "Sandy's Journey to the Sea," one for each student
2. Blank lined paper, one for each student

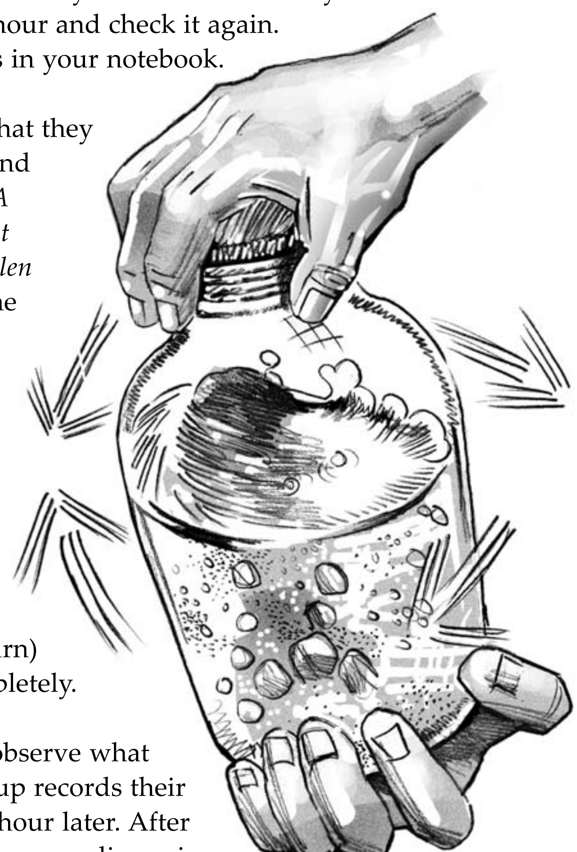
Activity 4.1a
The Layered Jar

(Adapted from: Crack, Crumble, and Carry, in The Layered Jar. *Naturescope Geology: The Active Earth.* National Wildlife Federation. Learning Triangle Press, 1997. Reproduced with permission of the McGraw-Hill Companies.)

1. Divide class into groups of 4-6 students, depending on number of jars you have collected. One jar per group.

2. Write the following instructions on the board, or print them out so students may follow the instructions as though they were conducting an experiment.

   1. Place one scoop of gravel in the jar.
   2. Place one scoop of pebbles in the jar.
   3. Place one scoop of sand in the jar.
   4. Place one scoop of soil in the jar.
   5. Fill the jar with water.
   6. Screw the cover tightly onto the jar.
   7. Shake jar GENTLY, enough to mix the materials but not so hard that the jar breaks. Turn the jar upside down and right side up three to four times, slowly. (The speed at which it mixes will not affect the final mixing result.)
   8. Set the jar down and write in your notebook what you observe inside the jar. Wait one hour and check it again.
   9. Write your observations in your notebook.



3. Begin by asking students what they think happens to river rocks and sand during big rainstorms. (*A jumble of river rocks and sand get carried downstream by rain-swollen rivers.*) What happens when the pulse of water in the river is over and things calm down? The jar is a model of what happens in a river during a storm.
Predict: What will happen when we shake the jar? Write predictions on board. Have students shake jars (all members of the group get a turn) until contents are jostled completely.

4. Students set jar down and observe what happens right away. Each group records their observations. Check again an hour later. After the second observation, lead a group discussion. Which material settled to the bottom first? Why? (*When a fast-flowing river carrying pebbles, sand, and soil begins to slow down, the heavier materials settle to the bottom first because of gravity.*) Which material settled last? Why? (*Lighter materials such as sand and silt require less force to be carried in water column, settle last, and are carried furthest downstream.)*

Preparation

Teach this as a small group activity, followed by a whole group discussion and individual reading/writing/illustration assignment.

Outline

One week before class:

1. Gather materials. One jar for every four to six students.

Day before class:

1. Photocopy "Sandy's Journey to the Sea," one for each student. **Optional**: you may read the story aloud to the students. In this case, do not photocopy the story.
2. Assemble jar and rock buckets in an area that can get dirty (outside the classroom may work best).

During class:

1. Divide class into groups of 4-6 students. Demonstrate how to make the layered jar. After jar activity is completed, lead whole class discussion on results.
2. Read the story aloud, OR hand out photocopies of story for students to read silently for 15 minutes. Lead classroom discussion. Students complete writing or illustration activity.

5. **Predict**: Based on students' observations, what do they predict a river mouth will look like after a storm? (*Lots more sand and silt in water.)* River flood plains and deltas are rich areas where much sediment has been deposited to create vast fertile growing areas, such as California's Central Coast (Salinas Valley) and the upper reaches of the San Francisco Bay/Delta (Sacramento and San Joaquin Valleys). Locate these deltas and fertile regions on a map of California and deltas all over the world. (*Egypt/Nile, London/Thames, China/Yangtze, Louisiana/Mississippi*). Why have people chosen to settle in these areas? (*Historically, humans have settled in rich river valleys and deltas initially because of the availablity and diversity of plants for food, then later farming opportunities because of the rich soil and availability of water.)*

Activity 4.1b
Sandy's Journey to the Sea Reading Activity

1. Students now have an idea of what happens to rocks and sand in water. To extend this knowledge, they will take an imaginary trip from the mountains to the sea that begins in the Sierra Nevada. On a map of California, have students locate the Sierra Nevada range, and identify some rivers that Sandy might travel on her long trip to the sea.

2. Hand out one copy of the story to each student or read the story to the students. Allow about 15-20 minutes.

3. After the students have read the story, lead a whole class discussion. Here are some sample questions: How did Sandy leave her original mountaintop home? *(The crack widened due to erosion; water from rain and snow carried her away.)* During the winter storm, Sandy became smaller and smaller until she was just a tiny sand grain. What caused this? *(Winter storm run-off carried her into the ocean where she was ground up against other rocks by waves.)* Sandy kept moving throughout the story. What forces moved her? *(Water: down the river and longshore ocean currents. Gravity: water flows downhill. Wind: waves and sand blowing across the beach.)* Waves in the winter are different from summer waves. How are they different? *(Winter waves are bigger and stronger and can move lots of sand quickly. Summer waves are smaller and gentler, and move the lighter sand easily but not the larger gravel and cobbles, which are under the sand and just offshore in the summer.)* How might a summer beach look different from a winter beach? *(The dry summer beaches are wider, gradually sloped, have more sand, and the sand is finer. Winter beaches are narrower, more steeply sloped, have exposed rock, gravel, or cobbles because the sand has been washed off the beaches by large storm waves.)*

4. Explain to students they will pretend they are Sandy, and are writing a letter "home." They describe their travels to those left behind. Home could be the mountain off of which she chipped, the lodgepole pine tree nearby, the river she lived near that eventually carried her downstream, etc. Students will write two complete paragraphs in a personal letter style. Students may read their letters to the class. Students may also make an illustration to accompany the letter; encourage students to include objects that Sandy would "see" (Sierra mountains/rock, tree; river/smaller rocks; beach/kelp, etc.).

Results and reflection

Student groups may create a postcard storybook.

1. Divide the class into groups of six.
2. Hand out to each student a blank 4" x 6" index card. Each of the cards will be a scene from Sandy's journey. Distribute a seventh card to each group to be a title card.
3. Review the six parts of the story with the class.
4. Pass out crayons, markers, or colored pencils to each group.
5. Assign each of the six students in each group a part of the story to illustrate Sandy on her journey and write a postcard home. Be sure they include Sandy in each picture. Students may write a couple of sentences on the back of the card as though it were a postcard, for example, "Dear Mom, Here I am, tossed on and off a sandy beach."
6. When the first person in the group finishes their card, they may write the title card that says "Sandy's Journey to the Sea."
7. Have students make a postcard storybook. Line all seven postcards in a row sequentially. Tape the short edges together, alternating the tape on the front and back to open and close like an accordion.

Conclusions

Sand on California's beaches begins as rocks in nearby or distant mountains. Storm swollen rivers carry rock particles downstream, tumbling and weathering them into even smaller pieces. By the time they reach the ocean, they are usually broken into sand-sized grains which are carried by waves and longshore currents along the coast.

Extensions and applications

1. Hold a classroom discussion on what would have happened to Sandy if she were in a river that was dammed for flood control or hydroelectricity. Would she make it to the sea? Where would she have ended up? What happens to dams if they stop many, many "Sandys" from going further downstream?
2. Locate on the map the larger rivers that are dammed. What might the beaches look like that are downriver from these dams?
3. Photocopy a small map of California. Students mark the locations of the major river deltas, research the timeline of the founding of nearby towns, and their commercial activities (farming, fishing, etc.).

Adapted from

Crack, Crumble, and Carry, from The Layered Jar. *Naturescope Geology: The Active Earth.* National Wildlife Federation. Learning Triangle Press, 1997. Reproduced with permission of the McGraw-Hill Companies.

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Sandy's Journey to the Sea

By Stephanie Kaza

Part 1: The High Mountains in Winter

High in the mountains, the rivers and creeks had begun to freeze over for winter. Golden aspen leaves fluttered down along the banks, leaving the white-barked trees empty against the blue sky. Already the craggy granite peaks of the High Sierra were deep in snow. On a ledge by a gnarled lodgepole pine was a small rock named Sandy. Smooth on one side, rough on the other, the rock was about the size of your thumbnail. It had broken off from a big mountain boulder and been caught in a crack for a very long time. Year after year, the small rock watched the seasons go by. But lately as the pine tree grew, Sandy noticed that the crack was getting wider and wider. She did not seem to be quite so stuck in her place anymore. She rattled a tiny bit and wondered if she would be there forever.

Part 2. The River Journey in Spring

One fine spring day, when the sun was out and beaming its hot rays onto the snow, a trickle of water crept underneath Sandy. It tickled a little bit and Sandy smiled in the warm air. As the day grew hotter, the little trickle turned into a rushing stream. Much to Sandy's surprise, she was lifted up out of her familiar crack and carried off over the edge of the granite.

Crash, bang! She tumbled down a roaring waterfall. In two seconds Sandy landed at the bottom in a deep pool, a little dazed. She barely caught her breath and was whooshed away down the racing river. She jumped and bumped through the raging rapids, sliding out of the high mountains to the foothills below.

Part 3: Oceanside Rest in Summer and Fall

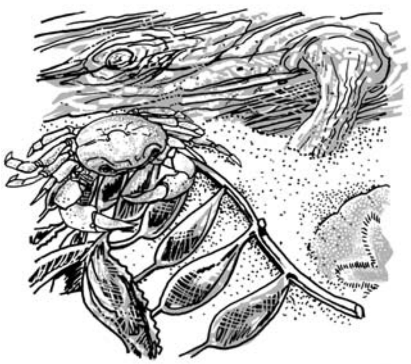
After quite some time and many miles, Sandy settled out on a flat spot perched on a riverbank not far from the sea. She had drifted by leopard lilies in spring and dragonflies in summer. During the dry months of fall the river had shrunk to a narrow creek, leaving Sandy high and dry. After such an exciting journey, she though she might just stay there awhile and rest. She hardly remembered her old crack, for she had been so many places since then.

As the season turned to winter, Sandy felt chilly in the cold night air. With all the wear and tear of going down the river, she was a little worn down. But she didn't mind, for the sky was brilliant with beautiful stars of many colors. One especially quiet night she gazed for hours at the silver dazzling full moon. In the early morning dawn she could barely hear the ocean's roar.

Part 4: The Winter Storm

Boom, crack! Just six hours later, the ocean was suddenly at her feet! It was high tide and winter storm waves were rolling in fast and hard, one right after the other. The rain pounded against the wild ocean. Before she knew it, Sandy was washed out to sea in a great churning of stones and sand. She barely caught one last look at her resting place, now so rocky and bare of sand.

Sloshing and grinding, the rocks crashed into each other in the open sea. Bit by bit, pieces broke off from Sandy until only a small sand grain was left. For days and days, Sandy tumbled around in the huge ocean, dancing on roller coaster waves and sinking in the silky blackness.



Part 5. The Kelp Wrack in Spring

After a month of gray skies and rain, the storm cleared. Sandy washed back up on the beach with may other sand grains. She herself was stuck to a big stalk of brown kelp. The waves carried her high above the tideline next to a driftwood log. She wondered if it might be her old friend the lodgepole pine.

As the sun grew hot, the kelp began to grow slimy and start to rot. Sandy was quite stuck in place, but at least she had many visitors. Flies and crabs nibbled at the kelp, gulls and shorebirds wandered by. It seemed there was always a party going on the kelp wrack. Out in the ocean, other sand grains waited underwater on sand bars for their time to join the party.

Part 6: The Summer Beach

As the days grew long and spring changed to summer, the beach once again grew wide and deep with sand. The kelp dried up and Sandy fell off onto the beach. People and dogs came by and scuffled the sand. Sandy hitched a ride on someone's toe and found herself at the edge of the ocean again. The waves were gentle now and spaced farther apart. At high tide she was scooped up in a quiet rocking motion and carried into the longshore current. Here Sandy drifted, pushed along the ocean, heading south with not much to do except go with the flow.

By the end of the summer, Sandy had traveled far from the kelp wrack beach. Now she was near a small coastal town by a large point of land. The nearshore current caught her up and pushed her on shore right next to a child building a sand castle. Scoop! The shovel picked her up and she landed at the bottom of the bucket. Splat! The bucket dumped her onto the top of the castle. She felt the child's warm hands patting her into a beautiful shape. Oh, how lovely! She could feel the child smiling, and she was glad to be there—at least for a while.

Grade 4 Activity

Science skills

- Observing
- Inferring
- Predicting
- Deducing

Concepts

- Observable characteristics of sand grains can provide clues to the origin of the sand.

California Science Content Standards

Earth Sciences

4. The properties of rocks and minerals reflect the processes that formed them. As a basis for understanding this concept, students will know:

4.a. How to differentiate among igneous, sedimentary, and metamorphic rocks by referring to their properties and method of formation (the rock cycle).

4.b. Know to identify common rock-forming minerals and ore minerals by using a table of diagnostic properties.

5. Waves, wind, water and ice shape and reshape Earth's land surface. As a basis for understanding this concept, students will know:

5.a. Some changes in the earth are due to slow processes, such as erosion, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

5.c. Moving water erodes landforms, reshaping the land by taking it away from some places and depositing it as pebbles, sand, silt, and mud in other places (weathering, transport, and deposition).

Activity 4.2
No Ordinary Sandy Beach

From mighty mountains come rivers of sand. Be a sand scientist in your own sand lab and see if you can trace sand to its origin.

Background

This activity builds on the knowledge students have gained from Activity 4.1b, *Sandy's Journey to the Sea*. Beaches come from rocks that have been weathered and transported by water to the ocean. Now we will determine exactly where sand samples have originated. What do we have to go on? We have maps and sand, a short list but a powerful combination when approached with an investigative perspective!

This activity is divided into two sections; *Sand Match Up* hones students' descriptive skills, and *A Chip Off the Old Block* is where students try to match the sand to rocks from which they came. The two activities can be carried out either sequentially in one day or over a two-day period. The *Sand Match Up* activity requires advance time for students to collect sand samples. **Begin collecting sand early in the year, over vacations.**

For Activity 4.2a, Sand Match Up: Make a Sand Sampler

This activity requires planning ahead. If your students begin collecting sand early in the school year before holidays, they can collect samples on their vacations or have their parents or friends collect samples on their travels.

Collect empty film canisters (obtainable from film processing businesses) and stick masking tape on canister for labeling. Hand out canisters and blank 3" x 5" card to each student. Students collect a sample of sand and place in film canister (one sample per canister). Samples can be found near a lake, stream, ocean, beach, wetland, river; any body of water will likely have some sand. Students put their name and collection date on canister label, but NOT the origin. Students put collection information on the 3" x 5" card: where the sample was taken (location and specific spot), date, person who took the sample, any other characteristics of the area (i.e. rushing river, calm lagoon, windy beach, steep beach with big waves, etc.). **Make a master list of where the samples came from, using a special code that is meaningful to you, but not to students!**

Make a sand "sampler" for each group of six students by pouring a small quantity of six different sand samples into separate plastic cups. Use different types of sand for each group so that the groups have different combinations of sands, with some sand samples the same, but not all six. Label the plastic cups with your special code.

Prepare a reference sand slide or petri dish:

To prepare the reference sand slides or containers:

a. Mix water with white glue that dries clear so the resulting mixture is thin.
b. Smear the thinned glue in the middle of the slide or container
c. Sprinkle the sand samples on the glue. NOTE: use just a little sand, so edges of the individual sand grains can be observed.
d. Label the location of collection using a small piece of masking tape on one side of the microscope slide or container.
e. The completed, labeled slides or sand containers serve as a "checking station" for students.

California History-Social Science Content Standards

4.1.1. Explain and use the coordinate grid system of latitude and longitude to determine the absolute locations of places in California and on Earth. (Ext. #3)

Objectives

Students will:

- Develop the skill of close observation.
- Describe where sand comes from, and how it becomes beach sand.
- Define the processes of rock weathering, transport, and deposition.
- Investigate sand samples to identify their properties and collect clues to their origins.

Time to complete

One hour for each activity (two hours total)

Mode of instruction

Over time and outside the class, students collect samples for the sand lab. Teacher prepares sand sampler. Groups examine samples and write observations, then compare observations with other groups. A whole class discussion on observable characteristics of sand is followed by students completing a worksheet on origins of sand samples.

Materials

1. Empty film canisters for sand samples (one per student)
2. 3" x 5" cards
3. Dissecting microscope (if available, one per group) and slides
4. Small, clear Petri dishes (for use with microscope)
5. Small plastic cups (one for each sand sample)
6. Hand lens (preferably one for each student)
7. Overhead transparency of map of local areas where sand was collected
8. "What's My Sand?" worksheet
9. "Sand Lab Data Sheet" worksheet
10. Dropper bottles of vinegar and salt water, one bottle per small group (Ext. 1b)
11. Magnets, one per group of six students (Ext. 2)
12. U.S. or world wall map (Ext. 3)
13. Overhead projector

Activity 4.2a
Sand Match Up (honing descriptive skills)

1. **Ask:** What do you know about sand? Are all sands the same? What are some of the differences? How do scientists describe the different types of sand? Write on board what students know about sand. They will now investigate different types and sources of sands.

2. Divide students into working groups of six and distribute a sand sampler (containing six samples) to each group.

3. Distribute a hand lens to each student with the instruction to examine one of the sand samples carefully and describe the sand in one paragraph on a 3″x 5″ card or piece of paper.

4. Direct each group to put their sand samples and description cards in the middle of their work station and shuffle them.

5. Have each group rotate to a different set of sand samples and description cards. The group challenge is to match each of the six sand samples with the correct description card.

6. Students return to original stations to see if the cards were matched correctly by the other students.

7. Lead a whole class discussion of sand matching successes and challenges. List observable characteristics of sand on the board (grain size, color, texture).

Activity 4.2b
A Chip Off the Old Block (matching sand to rocks)

1. Explain that observable, physical characteristics of sand provide some clues to its origin. Ask students for their ideas about the ways sand is created and what observable characteristics might result.

2. Distribute worksheets "Sand Lab Data Sheet" and "What's My Sand?" to each student, and discuss the physical appearance of the different sands listed (mineral, volcanic, or shell sand). List on the board the different characteristics of each sand type.

3. Each student closely observes her or his sand sample and completes the chart on the "Sand Lab Data Sheet," recording observations and inferences for her sample. For the second to last question on the worksheet, display the list of locations where the sand samples were collected and ask students to guess where their samples were collected.

4. Display reference sand slides or containers labeled with location of collection and have students check their guesses by comparing their samples with sand in containers or on slides. Allow time to observe a variety of samples for comparison; dissecting microscopes help.

Preparation

This activity takes some time to prepare but is well worth the effort. Get a head start—collect samples early in the school year.

Outline

Before Class

1. Students collect sand samples.
2. Make master list of sample locations.
3. Prepare reference slides or dishes.
4. Photocopy "What's My Sand" and "Sand Lab Data Sheet," one for each student.
5. Make overhead transparencies of Sand Types master and a map of local areas where most sand was likely collected.
6. Create sand sampler stations for groups of 6.

During Class

1. Students make observations at their original station.
2. Groups rotate to next station. Match up cards with samples.
3. Groups rotate back to original station and determine if the visiting group matched up samples correctly.
4. Classroom discussion on observable characteristics of sand.
5. Students complete "Sand Lab Data Sheet."
6. Students check reference slides to see if they correctly determined the source of their sand sample.

Results and reflection

1. How many students were able to successfully identify the source of the sand? What observations did they make to identify the source? (*Characteristics such as smoothness/roughness, color, size, shape of individual grains.*)
2. How do students think the sand ended up where it did? (*Some samples may have been transported from other sites by truck, such as sand in playground sand boxes, or from a construction site, while most other sands were transported by water.*) What observations support their hypotheses?
3. How would this activity be different if you were in a classroom in Hawaii? On a coral reef? (*Sands from the same source, either volcanic or shells*)
4. Why would some beaches have coarse sand or gravel, and others have fine sand, even though these beaches may not be far from each other? (*Coarse sand is an indication of "younger" sand or higher wave energy, recently eroded from parent rock and found near origin. Fine sand is long eroded from parent rock and far from its origin; wave energy creates finer sand. The angle of the beach to the waves may affect the size of the sand particles.)*

Conclusions

Moving water erodes landforms, reshaping the land by taking it away from some places and depositing it as pebbles, sand, silt, and mud in others. Close observation of sand yields clues to the origin and type of rock from which it came. Small details can yield large bits of information.

Extensions and applications

1. Does the sand come from rocks or bits of shell, or both? A simple acid test using vinegar (an acid) will identify shell pieces in sand samples: shells are made of calcium carbonate which will "fizz" as they react with vinegar. Students may place a few drops of vinegar on a sand sample to see if it contains shell pieces, then guess the origin of the sand (rock or shell).
2. The rate at which shells dissolve are affected by alkalinity (pH). Conduct this experiment as a class.
   Prepare two containers:
   a. In one container, place broken shells with salt water.
   b. In the second container, place broken shells with vinegar (acid).
   c. Students predict what will happen to the shells in each container. Observe the shells after several hours, after one week? Two?
   d. Repeat the above experiment with beach sand.
3. Magnetic Attraction: Place a pinch of sand on a sheet of paper, then move a magnet under the paper. If some of the grains are attracted by the magnet, they are likely to be the mineral magnetite (iron oxide). Magnetite grains are black or very dark gray.
4. Find Your Sand: Students mark the sand collection sites on a map, creating a wall chart noting the latitude and longitude of the locations, along with the type of sand found there. Each student will be responsible for mapping at least one collection site and for noting his or her explanation of why a certain type of sand is found there.

Adapted from

No Ordinary Sandy Beach, from For SEA Institute of Marine Science.
P.O. Box 188, Indianola, WA 93842. *www.forsea.org*

Additional References

www.paccd.cc.ca.us/instadmn/physcidv/geol_dp/dndougla/SAND/SANDHP.htm

Sand Lab Data Sheet

What characteristics of sand apply to your sample?

1. Is your sand ABIOTIC or BIOTIC?

ABIOTIC SAND:

- Is not made from shells, coral, or parts of living things.
- Is often made from eroded continental rock, such as granite.
- Usually contains a lot of clear quartz grains. Quartz is harder than other minerals, so it remains after other grains have worn away.
- Often includes dark mineral grains which may be biotite, magnetite, amphibole, or pyroxene.
- Might be volcanic sand: material from eruptions that cooled, hardened, then shattered or eroded into sand-size particles which are often black or shiny.

BIOTIC SAND:

- Is made from parts of living things: pieces of shell, coral, sea urchin spines.
- Is found on beaches in tropical areas where coral grows.
- Often shows pink or white colors.

2. Is your sand "OLD" or "YOUNG"?

"OLD SAND":

- Was long ago eroded from its parent rock, and is often far from its origin.
- Is well sorted, with all of its grains generally the same size.
- Has no skeletal remains that are easily identified.
- Is smooth, with no sharp edges on the grains, often rounded.
- If it is continental sand, it will be mainly quartz, other (softer) grains will have worn away: the sand will look mostly clear or glassy.

"YOUNG SAND":

- Is more recently eroded from its parent rock, so it is often found near its origin.
- Contains grains that are not well sorted, with many sizes present in one sample. (However, even "young" beach sand is well sorted; in general, river sand would be less well sorted.)
- Would still show skeletal remains.
- Contains angular or sharp grains that are rough, not rounded.
- If it is continental sand, it will have other minerals present along with the quartz grains, unless the parent rock is sandstone.

Note: there are always exceptions to these "rules!"

My sand is:

1. (Circle one) Mostly mineral sand Mostly volcanic sand Mostly shell sand

2. (Circle one) Near to origin (young sand) Far from origin (old sand)

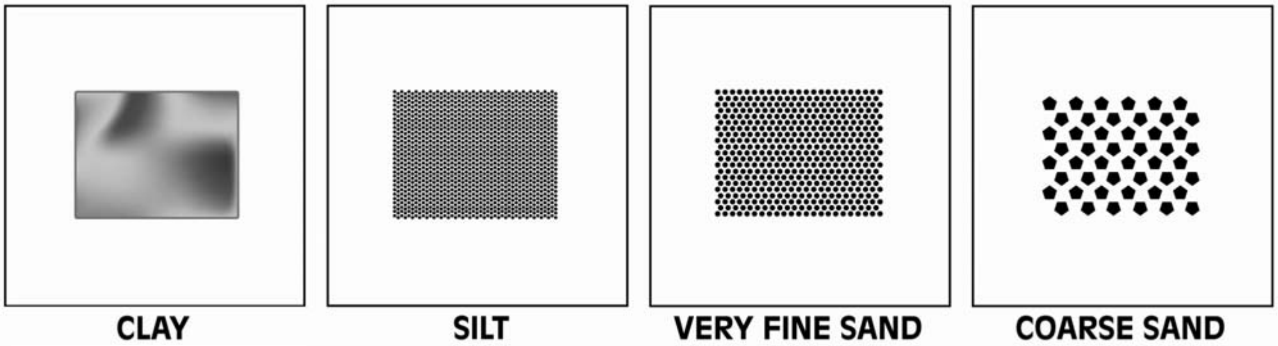
3. Physical appearance____

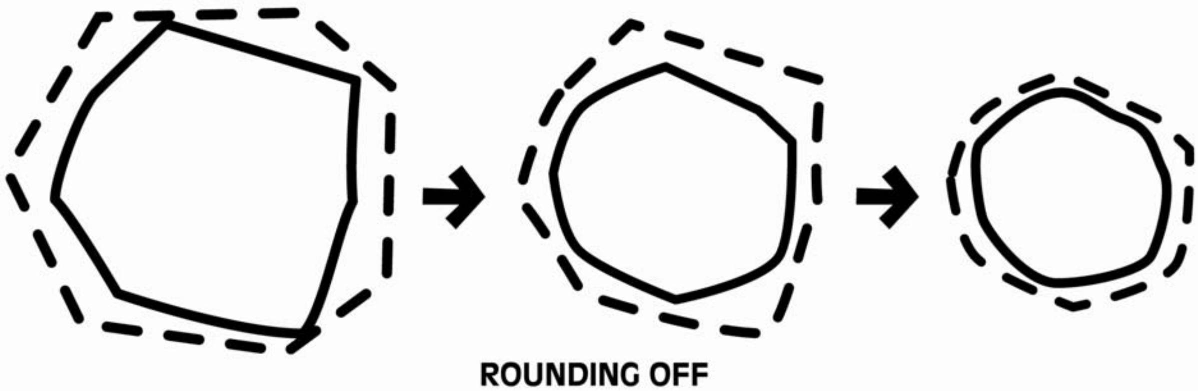
4. Observations ____

5. I think this sand sample was collected from ______________________________
(Check the list of locations where sand samples were collected.)

6. What did you successfully infer ("figure out") about your sand sample?

What's My Sand?





Sand: Take a Closer Look

We can learn a lot by looking closely at sand. By carefully examining the composition, size, rounding, and sorting of sand we can infer how far it has traveled, and from where and what type of rocks it came. Scientists classify sand according to two characteristics, grain size and texture.

Grain Size
Whether a material is gravel, sand, silt, or clay depends on the size of the individual grain: Gravel is material greater than 2 mm, including pebbles (4 - 64 mm) and granules (2 - 4 mm). Sand is material between 2 mm and 0.06 mm, and is divided into very coarse, coarse, medium, fine, or very fine sand. Very fine sand is the smallest grain size you can still see with the naked eye. Silt is finer than sand, but still feels gritty. Clay is the finest material of all, like flour, and forms a sticky ball when wet.

Texture
Whether a material has been transported a great or short distance can be seen by its texture; very coarse material indicates a short distance. The three guides used to understand the texture of sediment are size, rounding, and sorting. As rocks move in water, they knock and rub against other rocks, which "rounds-off" their sharp edges and corners. A well-rounded sand grain likely traveled a great distance from its original source area, while a sharply angled grain has probably not been transported very far. Rounding is also related to the size of the grains—boulders round more quickly than sand grains because they strike each other with greater force. Wind or water sorts rocks and sand; as they work they separate by size. The heavier, larger rocks settle to the bottom, while the lighter sand remains on top, kept constantly in motion by wind or water.

Grade 4 Activity

Science skills

- Observing
- Predicting
- Experimenting

Concepts

- Shape and composition of beaches result from interactions of many factors, including angle and orientation of the beach, size and frequency of the waves, and size and composition of the substrate.
- Seasonal changes, coastal development, and the presence of dams upstream can impact the intertidal.

California Science Content Standards

Earth Sciences

5. Waves, wind, water, and ice shape and reshape Earth's land surface. As a basis for understanding this concept, students will know:

5.a. Some changes in the earth are due to slow processes, such as erosion, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

5.c. Moving water erodes landforms, reshaping the land by taking it away from some places and depositing as pebbles, sand, silt, and mud in other places (weathering, transport, and deposition).

California Mathematics Content Standards

Measurement and Geometry

3.5. Know the definitions of a right angle, an acute angle, and an obtuse angle. Understand that 90°, 180°, 270°, and 360° are associated, respectively, with 1/4, 1/2, 3/4, and full turns.

California English-Language Arts Content Standards

Listening and Speaking

1.1. Ask thoughtful questions and respond to relevant questions with appropriate elaboration in oral settings.

1.2. Summarize major ideas and supporting evidence presented in spoken messages and formal presentations.

Activity 4.3 Beach in a Pan

Build a model of a beach and explore the forces that shape it. Is it a good idea to build a house on the sand or a beach cliff? Find out!

Background

As anyone who has spent a windy day at the beach getting sandblasted can tell you, beaches and dunes are dynamic systems. Sand is constantly in motion; it moves down the coast, up and down the beach face, and inland into dune fields. Wind and waves are natural forces that move sand from nearshore to onshore and back again, while California's longshore currents silently move the sand underwater.

With each wave the beach is changed. The force of the waves moves sand onshore during the summer, and offshore during the winter. Gentle summer waves bring sand from underwater sandbars just offshore to replenish the beaches. Stormy winter waves wash away beach sand that has built up over the summer and deposit the sand in the nearshore, creating underwater bars.

For the most part, the shape of the coastline determines the shape of the beach. Straight beaches are commonly found along low sandy coasts, such as much of southern California and the Monterey Bay. Pocket beaches and crescent shaped beaches are found along coastlines dominated by cliffs, such as the Big Sur coast and northern California. Variables that affect beach shape include the shape and relief (mountains or lowlands) of the coast, the resistance of the coastal materials to erosion, and the angle of approach of the waves.

Erosion is a natural process caused by weathering and wave action on the continent. Beaches protect ocean cliffs from erosion. Ocean waves must first remove or erode the beach before they can attack the cliff. Many sea cliffs are formed by the action of waves striking the coastline, a process that breaks down and removes rock from the cliff face. This erosion keeps the cliff face steep and results in a slow retreat of that cliff. The broken-down rock fragments become part of the beach. Some rock types, such as granite found along the Big Sur coast, are harder and more resistant to erosion.

The more beach sand and the wider the beach, the less cliff erosion will occur. Reduce the beach's width or size, and the potential for cliff erosion increases dramatically. Along with natural forces that shape our beaches are the unnatural forces created by humans. Coastal development, harbors, jetties, cliff armoring, and dams on rivers affect the shape and size of many of California's beaches.

Objectives

Students will:

- Create a model of a beach and conduct experiments with waves.
- Design an experiment to test the effect of natural and human created disturbances to beaches.
- Discover natural and human created impacts on beach formation.

Time to complete

1.5 hours

Mode of instruction

Students watch a video, then use models of a beach to test different variables.

Materials

1. Video available to borrow—*Beach: A River of Sand* (order in advance: *www.coastforyou.org*, 800-Coast-4u)
2. Two paint roller pans or rectangular baking pans for each group
3. A 3"x5" wave maker for each group (plastic or wood works best, but cardboard or an index card will work)
4. Sand: at least two different samples of different grain size. Two or more cups of sand per model, depending upon the size of the pan.
5. Gravel or small rocks
6. Larger rocks, about 2" in diameter
7. Water (three or more cups per model depending upon the size of the pan)
8. Sponges
9. Paper hole punches (colored papers)
10. Plasticene clay
11. Popsicle sticks or similar material
12. Copies of "Beach in a Pan" worksheet (one per student)

Preparation

1. Two-three weeks in advance: order video from Coastal Commission.
2. Gather one set of materials for each group of four students, or create two demonstration models (two models, groups take turns). Allow 30 min. for each group.The activity will take place over the course of 2-3 days.

Outline

Before class

1. Gather materials, photocopy worksheet.
2. Make two demonstration models.
3. Set up materials for students.

During class

1. Watch video.
2. Discuss factors that shape beaches.
3. Demonstrate beach model.
4. Hand out model materials, worksheet.

Activity

1. Begin the lesson by reviewing what students know about the sand that moves along our coast. Where does it come from, where does it go, and how does it affect our lives?

2. Hand out "Beach in a Pan" worksheet. Show video *Beach: A River of Sand* (order in advance from the Coastal Commission).

3. After the video, lead a whole class discussion. Topics may include:
   a. What are factors that might influence the shape of a beach?
   b. Why would you find different kinds of plants, algae, and animals on a rocky shore than at a sandy beach?
   c. What kind of beach would stay the same (have the most stability) over time? What maintains that stability? What events change it?
   d. In California, which direction does the longshore current run?

4. Divide students into groups of four to set up beach models and record their results on the back of worksheet. Alternatively, create two demonstration models for student groups to take turns conducting experiments.

Results and reflection

1. Each group of students presents their experimental findings to class. Discuss what they decided was more important in shaping their beaches: the slope of the beach, the size, frequency or angle of the waves, materials that make up the beach, or some other variable.
2. If you wanted to build a house with an ocean view, where would you build it? Have students write a one paragraph description of how they could get an ocean view without having to worry about the cliff eroding under their house, or a wave crashing through a window.

Conclusions

Sand is constantly in motion. Water, waves, and wind are physical forces that move sand. Beaches are shaped seasonally by waves; coastline orientation and rock type also play a role in the long-term shape of a beach. Coastal erosion is a natural phenomenon, one we must learn to live with. Humans can affect beach formation by constructing jetties, harbors, and cliff armoring. Potential changes to beaches should be thoroughly investigated before structures are built, as public beaches may be adversely affected.

Extensions and applications

Nothing beats a field trip to the beach! Visit the beach in winter and the same beach in late spring. In most cases, the class will see two very different beaches. Conducting a beach profile is an excellent way to visualize the changes a beach goes through over the year (See Activity 6.1). Check a tide table before you go.

Adapted from

Beach in a Pan. ©Monterey Bay Aquarium Foundation, 2000. This activity was developed by educators at the Monterey Bay Aquarium. For information about aquarium activities, exhibits, and classes, visit *www.montereybayaquarium.org* or call (831) 648-4800.

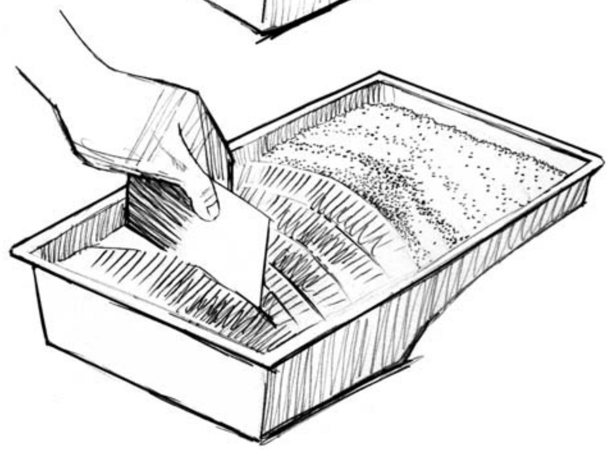
Additional references: *A Natural History of the Monterey Bay National Marine Sanctuary*, Monterey Bay Aquarium, 1997.

Beach in a Pan

LOOK: Watch the video *Beach: River of Sand*. While watching, pay careful attention to the material on the beach where the waves break, the size of the waves, and how often the waves hit the beach.

MAKE A MODEL OF THE BEACH:

1. Pour the sand into the shallow end of the paint pan.
2. Shape the sand to form a flat rectangle filling the shallowest section of the pan.
3. Slowly pour the water into the deep end of the pan.
4. Using the plastic or wood "wave maker" practice making waves in the pan. The goal is to make waves of a consistent height and frequency.
5. Once you have "mastered" wave making, reshape the sand in your pan as it was in step 2.
6. Sketch a profile (side-view) of the sand in your pan.
7. SLOWLY make waves which sweep up onto the sand. Keep making waves until over half of the sand is washed from the sand pile and extends down the slope toward the deep end of the pan.
8. Sketch a second profile of the way the sand looks in your pan now.
9. Compare your beach profiles with those of other students in your group.



GUESS: Discuss with your group the differences and similarities of the various beach profiles? Why do you think there are so many variations? What causes beaches to have different shapes? Do beaches change over time? Which is more important: the angle of the beach, the size and frequency of the waves, the angle at which the waves hit the beach, or the materials that make up the beach?

TEST: Using the materials provided by your teacher, make a second beach model to test your ideas. Your second model has to be exactly the same as your first model except for ONLY ONE characteristic, the "experimental variable." You may want to experiment with angle of the beach, the size, frequency or angle of the waves, the materials that make up the beach, or some other idea of your own (see "Experimental Variables" box).

TELL: Share and compare your findings with others in your group.

LOOK AGAIN: Use your models to predict, then test, the effect of one of the following on a beach: winter storms, coastal development, the construction of a harbor or jetty, presence of submarine canyon, damming of a river. Draw an illustration of your results.

Experimental Variables

- slope of the beach (increase elevation of the beach by placing a book under the sand end of pan)
- angle that the waves hit the beach (i.e., at a right angle or at acute angles such as 60° or 45°)
- size and frequency of the waves (make wave maker go faster or slower, vigorous or gentle)
- wind (blow on the waves)
- dune plants (add toothpicks or small grass-like plants)
- structures such as jetties (popsicle stick) or beach armor (a small pile of rocks)
- cliffs (make cliffs of plasticene clay)
- detritus or oil (colored paper spread on water)

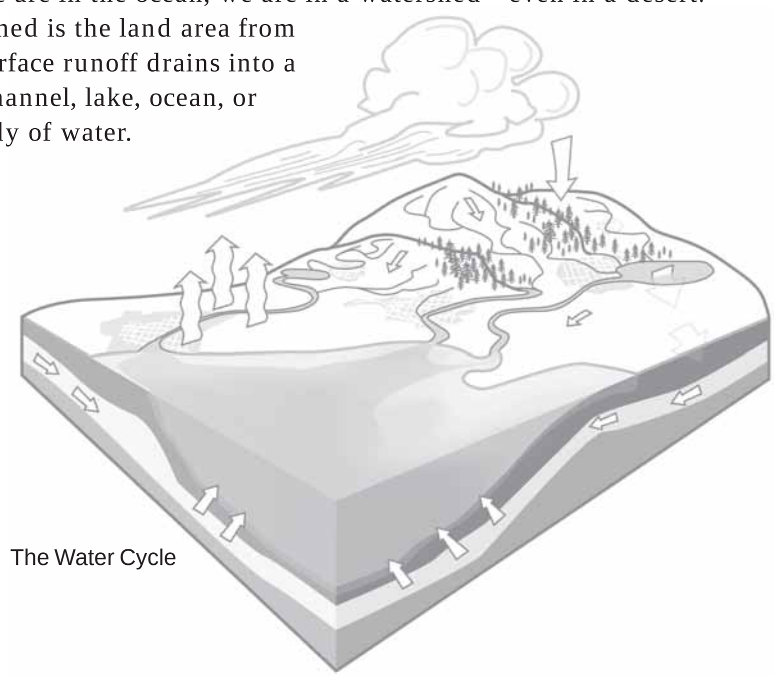
Chapter 5
Water, Water Everywhere

What is the most important resource on Earth? Water! Think of it: Almost everything we do involves water, from the food we eat to brushing our teeth. We use a lot of water, but there is a fixed amount of water on Earth and in its atmosphere. What makes this possible is that water is recycled through Earth's water cycle, the *hydrologic cycle*. Though 71 percent of our planet is covered by water, people can't use most of it because it is seawater, frozen at the poles, or deep underground. Only 0.003 percent of all water on Earth is clean, fresh water that is usable. As Earth's population continues to grow, clean water is becoming a limited resource. How we care for our water influences our daily lives, affects life on land and in the oceans, and shapes our future on Earth.

Water on Earth moves between the atmosphere, land, and oceans in a journey known as the hydrologic or water cycle. Water falls from the atmosphere as snow, hail, or rain onto land and ocean. The sun's heat provides energy to evaporate water from Earth's surface water (oceans, lakes, etc.). Plants also lose water to the air in a process called transpiration. The water vapor eventually condenses, forming tiny droplets in clouds. When the clouds meet cool air over land, precipitation in the form of rain, sleet, or snow is triggered, and water returns to the land or sea. Some of the precipitation soaks into the ground. Some of the underground water is trapped between rock or clay layers; this is called groundwater. But most of the water flows downhill as runoff, eventually returning to the sea.

New Words
watershed; hydrologic cycle (water cycle), point and nonpoint source pollution

Water travels over land through *watersheds*. Wherever we are on Earth, unless we are in the ocean, we are in a watershed—even in a desert! A watershed is the land area from which surface runoff drains into a stream channel, lake, ocean, or other body of water.


The Water Cycle

California Coastal Commission Area of Critical Concern: Water Quality and Wetlands

Relevant California Science Content Standards, Grade 5: Earth Sciences 3.a, d, e

Grade 5 Activities

These activities focus on water: its sources, cycles, and uses. Students will gain an appreciation of this valuable and limited resource, learn from where their domestic water comes, and learn actions they can take to conserve it.

Activity Goals

5.1. A Drop in the Bucket

Students will:

1. Calculate the percentage of fresh water available for human use.
2. Explain why water is a limited resource.

5.2. Alice in Waterland

Students will:

1. Trace their domestic water to its source prior to human use and to its destination after use.
2. Identify potential effects from human water use on terrestrial and aquatic wildlife.
3. Develop and practice responsible water conservation behaviors.

5. 3. Branching Out!

Students will:

1. Predict where water will flow in watersheds.
2. Describe drainage patterns in watersheds.

Tracking water from its source, to its uses, to where it ends up helps us understand why water is a precious resource, especially in California. In the northern part of our state, we have little summer rain to replenish water supplies that are drained by use over our dry summers. The southern half of our state is relatively dry year round, and does not receive much rain in the winter or spring, either. Water from northern California is transported to southern California via the California Aqueduct and the Central Valley Project. This water comes from snow runoff from the interior mountain range, the Sierra Nevada.

Water—how much there is, and how clean it is—is one of the biggest issues we Californians will face in the future. Available water will determine our daily water use habits, what we eat, how much we pay for it, where we go for vacations, and where we live. We need to manage our use of clean water so there is enough to maintain wetlands and natural places, for agriculture, home use, for electricity, and to support business and industry. There are many things we can do to make sure that water entering wetlands and the ocean is not harmful to the plants and animals that live in these habitats, and we can learn about ways that we can keep the water clean in rivers, lakes, and the ocean.

What happens when we don't take care of our water?
Polluted runoff, watersheds, and wetlands!

Polluted water reaches coastal streams, wetlands, and our oceans from both *point sources* and *nonpoint sources*. Point sources are those that can be traced back to a particular place, usually an outlet or pipe from a stationary location, where pollution is dumped or discharged into a body of water. Because point sources originate from one particular place, there typically are just one or a couple of kinds of pollutants introduced to the water.

Nonpoint source pollution, on the other hand, comes from many diffuse sources across the land. It originates when rainfall, snowmelt, or irrigation runoff flows over the landscape and picks up pollutants as it heads for larger water bodies. These pollutants might consist of oils and greases, metals, bacteria, trash, pesticides, or other contaminants depending on the areas the water runs over before reaching the ocean. In agricultural areas, pesticides, sediments, and nutrients are the prime types of pollution for wetlands, waterways, and the ocean. Runoff in urban areas carries oil dripped from cars, trash, plastics and pet waste from the streets and sidewalks, and an assortment of chemicals (detergent, lawn fertilizer, paint, insecticides) from every day life.

When pollutants enter wetlands and oceans they can harm the plants and animals that depend upon clean water to live. Luckily, there are plenty of things people and cities can do to prevent nonpoint source pollution and to provide for healthy oceans in the future. We can practice wise water use, watch what we put down household drains and storm drains, and be aware of the chemicals we use in gardens—every little effort goes a long way. See page 55 for more tips.

Grade 5 Activity

Science skills

- Calculating
- Predicting
- Inferring
- Graphing

Concepts

- Though nearly three-fourths of Earth is covered with water, there is a finite amount of water on Earth.
- Very little (.003 percent of the total amount of water on Earth) is potable.
- Contamination of fresh water resources reduces the amount of water available for all life.

California Science Content Standards

Earth Sciences

3. Water on Earth moves between the oceans and land through the processes of evaporation and condensation. As a basis for understanding this concept, student will know:

3.a. Most of Earth's water is present as salt water in the oceans, which cover most of Earth's surface.

3.d. The amount of fresh water located in rivers, lakes, underground sources, and glaciers is limited and that its availability can be extended by recycling and decreasing the use of water.

3.e. Students know the origin of the water used by their local communities.

Activity 5.1
A Drop in the Bucket

Earth is a water planet, but when you break down the percentages, there isn't much clean water for us to use.

Background

Ironically, on a planet extensively covered with water (71 percent), this resource is one of the main limiting factors for life on Earth. The "Water Availability Table" in this activity summarizes the major factors affecting the amount of available water on Earth.

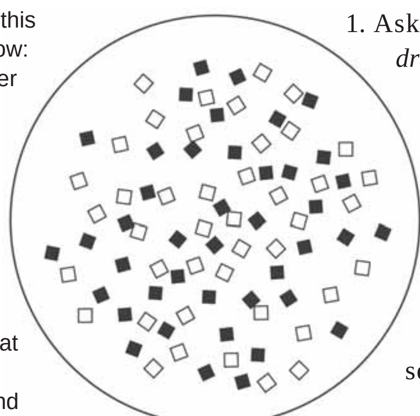
If all the clean, fresh water were distributed equally among all people, there would be about 1.82 million gallons (7 million liters) per person. While this is a large amount per individual, it is only about 0.003 percent of the total amount of water on Earth—not very much in the big picture.

For some, water may appear to be plentiful, but for others it is a scarce commodity. Why are some people in need of water while others have more than they need? Where you live and how you use water makes the difference. Geography, climate, and weather affect water distribution. Agriculture, industry, and domestic use affect availability.

The water we drink and use every day comes from our watershed. In the U.S., 61 percent of our population relies on lakes, rivers, and streams as our source of drinking water. The other 39 percent rely on groundwater that they pump from the ground.

This activity is broken into two sections: In *How Much Potable Water Is There?*, students predict the proportion of potable water on Earth; and *A Drop in the Bucket* is a teacher-led demonstration of the surprisingly small amount of potable water on Earth.

Activity 5.1a
How Much Potable Water Is There? Predict!



1. Ask students "What is 'potable' water?" (*Water suitable for drinking.*) What are some undrinkable waters? Students are to predict the proportion of potable water on Earth compared to the rest of the water on the planet. Students work in small groups (4-6 students). Hand out paper to groups (one sheet white paper, one sheet each of two different colors). Have one student in each group draw a large circle with a marker on the white sheet of paper. One of the colored papers represents available fresh water (potable water); the other represents the rest of the water on the planet.

2. Instruct students to tear the two sheets of colored paper into a total of 100 small pieces. Ask them to predict how many pieces will represent potable water and how many pieces will indicate the rest of the water on the planet. Instruct each group to arrange the 100 pieces within the circle so that these pieces reflect their predictions. Have groups record the

California Mathematics Content Standards

Number Sense

1.1. Estimate, round, and manipulate very large (e.g., millions) and very small (e.g., thousandths) numbers.

1.2. Interpret percents as a part of a hundred; find decimal and percent equivalents for common fractions and explain why they represent the same value; compute a given percent of a whole number.

Objectives

Students will:

- Calculate the percentage of fresh water available on Earth for human use.
- Know Earth is covered mainly by water, but that only a small amount is available for human consumption.
- Explain why water is such a limited resource.
- Appreciate the need to use water resources wisely.

Materials

1. Two colors of construction paper for each group of four students
2. Sheets of white paper
3. Markers
4. Water
5. Globe or world map
6. 1000 ml beaker (or a clear 1 liter bottle)
7. 100 ml graduated cylinder
8. Small dish
9. Table salt
10. Freezer, ice bucket, or ice cube tray
11. Eyedropper or glass stirring rod
12. Small metal bucket
13. Photocopies of "Water Availability Worksheet," one per student

Time to complete

One hour

Mode of instruction

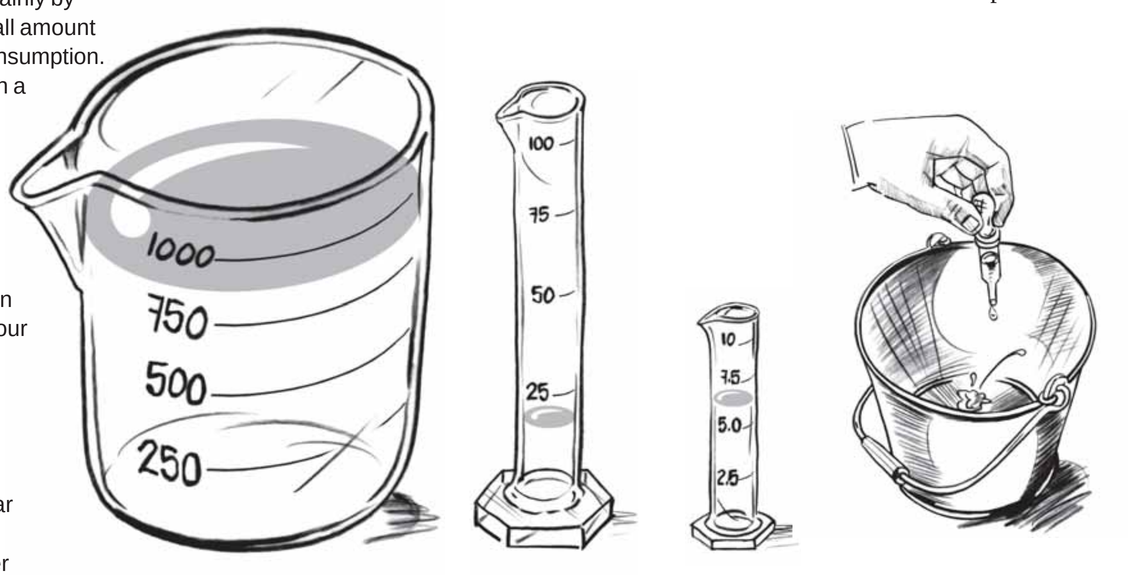
Small group activity followed by teacher demonstration, student worksheet, and whole class discussion.

number of pieces representing "potable" and "remaining" water. Have students translate these numbers into percentages, fractions, and decimals. (If they predict the amount of potable water to be ten pieces of paper out of 100, this is equivalent to 10%, 10/100=1/10, and 0.1.) Students write their numbers on the sheet of paper and set aside for later discussion.

Activity 5.1b
A Drop in the Bucket

1. Set all materials on table in front of students. Show class a liter (1000 ml) of water and tell them it represents all of the water on the planet.

2. Ask students where most of the water on Earth is located (refer to a globe or a map of the world). Pour 30 ml of the water into a 100 ml graduated cylinder. This 30 ml represents Earth's fresh water, about 3 percent of the total amount of water on Earth. Put salt into the remaining 970 ml in beaker to simulate ocean salt water unsuitable for human consumption.



1000 ml (total on Earth) 30 ml (fresh) 6 ml (non-frozen fresh) 0.03 ml (potable)

3. Ask students what is at Earth's poles. (*Almost 80 percent of Earth's fresh water is frozen in ice caps and glaciers.)* Pour 6 ml of the 30 ml of fresh water into a small dish or cylinder and place the rest (24 ml) in a freezer, ice bucket, or ice cube tray. The 6 ml in the dish or cylinder (around 0.6 percent of the total water) represents non-frozen fresh water. Only about 1.5 ml of this water is surface water; the balance is underground, unavailable, or is not potable.

4. Use an eyedropper or a glass stirring rod to remove a single drop of water. Release this one drop into a small metal bucket (one drop equals about 0.03 ml). Students must be very quiet to hear the sound of the drop hitting the bottom of the bucket. This represents clean, fresh water that is not polluted or otherwise unavailable for use, about 0.003 percent (three thousandths of a percent) of the total amount of water on Earth! Write "0.003 %" on the board.

5. Discuss results of demonstration. A very small amount of water on Earth is available to humans.

Preparation

Collect materials. Review concept of percentages with students. This is a fun and relatively easy activity.

Outline

Before class

1. Collect materials the week before
2. Set up for classroom demonstration.
3. Photocopy "Water Availability Table," one per student.

During class

1. Hand out two pieces of white paper and two pieces of different colored paper to each group.
2. Conduct student predicting activity.
3. Conduct teacher-led demonstration.
4. Hand out "Water Availability Table" to each student. Complete worksheet.
5. Whole class discussion on demonstration.
6. Whole class discussion comparing results of student predictions to teacher demonstration.

ANSWER KEY 5.1b Water Availability Table

Total Water (100%) on Earth divided among all people (based on a world population of 6 billion people)
= 233.3 billion liters/person

Minus the 97% of each share (226.3 billion liters) that contains salt (oceans, seas, some lakes and rivers) 233.3 – 226.3 billion liters
= 7 billion liters/person

Minus the 80% of this 7 billion that is frozen at the poles (5.6 billion) 7 – 5.6 billion liters
= 1.4 billion liters/person

Minus the 99.5% of the 1.4 billion that is unavailable (too far underground, polluted, trapped in soil, etc.) (1.393 billion) 1.4 – 1.393 billion liters
= 7 million liters/person

Results and reflection

1. Students retrieve their earlier guesses at how much water on Earth is available to humans, and compare them to actual percent that is available. **A little more than one-half of <u>one</u> of the 100 pieces of colored paper represents potentially available water (0.6 percent.) Only one small corner of this half (0.003 percent) is potable water.** Have students explain their reasoning for their initial predictions. How would they adjust their proportions? Complete "Water Availablity Worksheet."
2. Ask students again if enough water is currently available for people. If the amount of usable water on the planet is divided by the current population of approximately 6 billion, 7 million liters of water is available per person. Theoretically, this exceeds the amount of water an individual would require in a lifetime, but keep in mind that humans use the majority of potable water for industry and agriculture, and that other organisms use water, not just humans.
3. Why does more than one-third of the world's population *not* have access to clean water? Discuss with your class the main factors affecting water distribution on Earth (e.g., land forms, vegetation, proximity to large bodies of water, economics, and politics), and the environmental influences that affect the availability of water (drought, contamination, flooding).

Conclusions

Though 71 percent of the Earth is covered with water, very little of this (0.003 percent) is potable, or usable by humans. We must take care of our fresh water resources to ensure there is enough water for the natural diversity of life on Earth.

Extensions and applications

1. Students develop a television commercial stating reasons why water is a limited resource.
2. Students can identify areas of the globe where water is limited, plentiful, or in excess and discuss the geographical and climatic qualities contributing to these conditions. For example, large variations in precipitation occur within states (Death Valley receives as little as 2 to 5 inches [5 to 12.5 cm] per year. Only 100 miles away, mountain ranges receive more than 30 inches [76 cm] per year. These variations dramatically impact plants, people, and other animals.)
3. Have students bring in newspaper or magazine articles about droughts and floods worldwide; identify the locations on a world map.
4. How would global warming affect the amount of usable water on Earth? (*Polar ice caps would melt, adding more water to the oceans; sea level would rise, putting low lying coastal lands and small islands in danger. Worldwide weather changes would occur, due to global ocean temperature changes.)* What areas of the world would be most affected? (*Low lying coastal areas.*) How would students' lives be changed by melting polar ice caps? (*Weather changes, coastal changes, food production changes, etc.*)

Adapted from

A Drop in the Bucket is used with permission from Project WET/Montana State University from the *Project Wet Curriculum and Activity Guide.* For further information about Project WET (Water Education for Teachers), contact the national office at (406) 994-5392, or the California Project Wet, Water Education Foundation, (916) 444-6240, *www.watereducation.org*

Water Availability Worksheet

How much water is there on Earth? Is it all usable? Is there enough usable water for everyone to have as much as they need? Use this table to calculate how much clean water is available for all our uses.

Quantity to be divided among all people on Earth	Amount available (liters per person)	Percentage of total water
All the water on Earth	233.3 billion	100%
Only the fresh water (calculate 3% of the total amount available)		
Only the non-frozen fresh water (calculate 20% of the remaining amount available)		
Available fresh water that is not polluted, trapped in soil, or too far below ground to use (calculate 0.5% of the remaining amount available)		

1. Where is all this water? Is it distributed equally around the world?

2. How will future population growth affect the amount of water available for us to use?

3. How will our lives be affected if we don't have enough clean water?

4. What can we do to make sure there is enough clean water in California's future?

Grade 5 Activity

Science skills

- Visualizing
- Estimating
- Extrapolating
- Analyzing

Concepts

- Water is a precious resource.
- How people use water may affect terrestrial and aquatic wildlife.
- In coastal towns of California, treated water from household waste often goes into the ocean, and untreated runoff goes down storm drains, which can lead to the ocean as well.
- Becoming aware of the many ways in which water is used will help students adopt a wise water use ethic.

California Science Content Standards

Earth Sciences

3. Water on Earth moves between the oceans and land through the processes of evaporation and condensation. As a basis for understanding this concept, student will know:

3.d. The amount of fresh water located in rivers, lakes, underground sources, and glaciers is limited and that its availability can be extended by recycling and decreasing the use of water.

3.e. Students know the origin of the water used by their local communities.

Activity 5.2 Alice in Waterland

Take a trip through your water faucet and learn more about your city's water system. Where does water come from? Where does it go?

Background

Water use is such an automatic and habitual daily activity that we often don't understand the consequences. Seldom do we connect the water that comes out of the faucet to its sources in the natural world.

A model that traces the dynamics of water is called the water cycle or the hydrologic cycle. The water cycle follows the path of water from when it falls in the form of rain or other precipitation on a *watershed* (the land area from which surface runoff drains into a stream channel, lake, ocean, or other body of water); to its travel as runoff that flows into streams, groundwater, lakes, reservoirs, estuaries and oceans; to its eventual return to the atmosphere through evaporation; to its formation into clouds; to its condensation in the form of precipitation as it falls on a watershed. The great storehouses of water—glaciers and icecaps—are also part of this cycle. All forms of life on Earth are dependent upon and affected by this cyclical journey of water.

In between water's source and the sea, we divert water from its natural course for our uses. About 8 percent of total water use in the U.S. is for domestic use, 33 percent is for agricultural purposes, and 59 percent is for industrial/commercial uses (U.S. Geologic Circular 1001). Each time we draw water from its natural setting or modify the natural journey of water, we are likely to have an impact on wildlife and habitats. For example, dams flood river and stream valleys, and draining wetlands removes water from natural wildlife nurseries.

Once water is diverted from its natural path and is used by humans, it is often contaminated or polluted. The effects of this polluted water may be devastating: salinity from irrigation damages soil's productivity, runoff containing agricultural fertilizers and pesticides impairs lake and river habitats, and toxic chemicals can poison human and wildlife water supplies. Contamination can enter the water cycle with damaging consequences for people, wildlife, and the environment.

Humans have choices in how we use and how we treat water. We can make decisions to use water respectfully and carefully, and conserve water as a part of our daily lifestyle. Water conservation reduces or prevents destruction of natural habitats by lessening the need for dams and other interventions. It also reduces the depletion of underground water stores which supply water for riparian and other habitats. Water conservation may also decrease wastewater discharges into sensitive environments such as estuaries.

In addition to conservation, we can also pay attention to what we put into water and the water cycle—being careful with potential toxins like pesticides, detergents, fertilizers, motor oils, aerosols, cleaning fluids

California Mathematics Content Standards

Statistics, Data Analysis, and Probability

1.2. Organize and display single-variable data in appropriate graphs and representations (e.g., histogram, circle graphs) and explain which types of graphs are appropriate for various data sets.

Objectives

- Students will trace their domestic water to its source prior to human use and to its destination after use.
- Students will identify potential effects from human water use on terrestrial and aquatic wildlife.
- Students will identify, develop, and practice responsible water conservation behaviors.

Time to complete

Two 45-minute sessions, plus time to draw murals. Two-week homework.

Mode of instruction

May be conducted indoors or outdoors. Teacher reads text for visualization exercise, followed by whole class discussion. Students create a mural based on visualization. Students keep track of water use at home, create a chart with total use of water by the class's homes. Students create a list of water conservation practices.

Materials

1. "Water Use Worksheet," one for each student (double-sided, cut in half, week one and week two will go home separately)
2. Long sheets of butcher paper for murals
3. Art supplies for murals

Preparation

If possible, contact your local water district, water treatment plant, or wastewater district to inquire whether they have educational materials to send out, or conduct tours for students. Gather and organize local knowledge and educational resources of water sources such as local reservoirs and rivers, and wastewater discharge (to a river, groundwater, or ocean). Gather materials, photocopy and cut "Water Use Worksheet" (double-sided).

and powders, and caustic acids, as well as fuels and their byproducts. We can affect both the quantity and quality of available water through our personal and public conservation practices.

This activity encourages students to develop a greater awareness of water use and the effects of water use on wildlife and habitats. In addition, students are encouraged to develop a personal ethic of responsible water use, and demonstrate it through their actions.

Activity

1. Tell students they are going on a simulated field trip. Just like Alice followed the White Rabbit down the rabbit hole, they are going to shrink down to a size that will let them travel up their faucets at home and into their water pipes. *You may want to adapt the text so it will apply to your local settings. If you are in a rural community and many of the students have well water as their domestic source, you can convert the simulated field trip to begin at a faucet there at the school.* Even if this text does not apply to all students' situations, it can be used to explore a typical source of water and its routes somewhere in California.

2. Ask students to picture in their minds what you will describe for them in the following words:
"Are you comfortable? Good. Close your eyes, and picture yourself small enough to climb into the faucet in your kitchen at home…see yourself with magic powers that allow you to travel through the water that comes from the faucet to its origins… You will be able to pass through all the pipes, valves, and other barriers on the way… The first part of the journey takes you through the pipes in your house to where they connect to your water source… If you live on a farm or ranch, the source would probably be a well or perhaps a spring. In the city, the water source for your home probably would be far away… First you get into a water main, the pipe that carries water to all the houses and businesses in your neighborhood…then you follow the main until you come to a pumping plant where water pressure is maintained… Past the pumping plant is a place where the water is purified… This may be very complex—a place with filters, chemical tanks, and treatment equipment… Beyond the purification plant, the water may be in an aqueduct or open channels coming from a reservoir… The reservoir is a huge lake where water is stored… There are often trees and bushes on its edges… Wildlife is common, fish are usually abundant and people might use the site for boating and fishing… Natural streams usually flow into the reservoir… They drain large areas of the land's surface which are called watersheds… A watershed is the land area that catches and transports water through streams, underground flow, and rivers… The water in a watershed contains all the water that is naturally available for use by all living things in that area… If you want, stay here. Try to see the plants and animals that live in the area. Or, follow your route all the way back through the reservoir and channels and treatment plant and pumping plant to the water main and the pipes in your house and out your faucet. Now, open your eyes."

Outline

Before Class

1. Photocopy "Water Use Worksheet," one sheet, double-sided. Cut into two halves; the second half ("Week 2") will have the "Wise Water Use Tips" on the back. For students to be able to see changes in their water use habits, be sure the students do not see the tip sheet until the second week.
2. Gather art materials for mural.

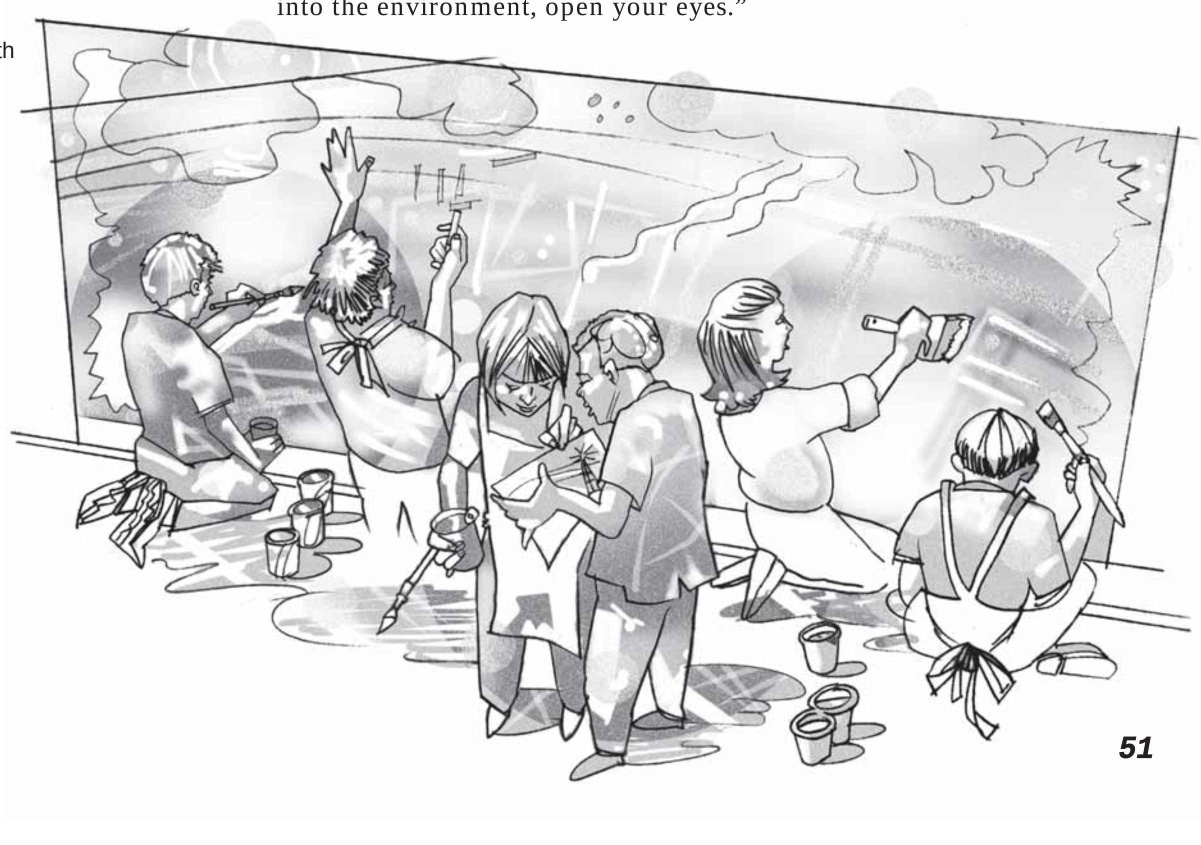
During Class

1. Whole class discussion on water use.
2. Read visualization text for simulated field trip from faucet to reservoir.
3. Whole class discussion of journey.
4. Read visualization text for simulated field trip from drain to ocean, river, or septic tank.
5. Whole class discussion of journey.
6. Students create murals of upstream and downstream.
7. On a Friday, hand out "Water Use Worksheet, Week 1." The next Friday, hand out "Water Use Worksheet, Week 2." Make sure the "Wise Water Use Tips" are sent home with students for Week 2 ONLY.
8. Students collect data beginning Saturday and continue through the next Friday.
9. After data has been collected for Week 1, make master chart summarizing use. Brainstorm water saving ideas.
10. Students gather data for another week; tabulate results.
11. Compare water use tables for both weeks.

3. After this simulated field trip, discuss as a group the journey of the water from its source to the faucet. Identify components of the journey. Emphasize places where wildlife habitat is affected—positively, negatively, or with unknown effects—by the intervention of people as they use the water or influence how water is to be used.

4. Have students create an "origins" mural on a single long sheet of butcher paper, depicting the origins and journey of water from their home to its source. Emphasize wildlife and habitat all along the way.

5. Repeat the process for a journey down the drain and into the wastewater system. Read aloud:
"Picture yourself small again. This time the journey will be down the drain in your sink. You move along through the used water system to a treatment site... If you live on a farm, the site will probably be a septic tank… A septic tank is usually a large concrete box… Here bacteria break down the substances carried in the water… Once the water is cleansed to the degree possible, it flows out through drainage fields and back into groundwater sources or streams… If you live in a city, there is much more water being used and large water treatment plants must attempt to cleanse the water before it is returned to rivers and streams… In these treatment plants there are great filters and holding tanks… The water must be held in place for solid substances to settle out by gravity… Air is often pumped through the waste water to increase the oxygen content so bacteria can break down the impurities more quickly… Eventually the treated water is released into rivers, streams, or the ocean… It again re-enters the natural habitat for wildlife… There it provides an essential component for continued life… If all was done well, animals, plants, and humans will safely re-use the water…It will nourish the crayfish caught by the raccoon…It will provide the pond for the turtle… It will provide the refreshing drink for someone like yourself in some downstream city… After you have followed the water out into the environment, open your eyes."



6. Repeat the discussion and create a "downstream" mural. Include places where humans and wildlife are affected—positively, negatively, or with unknown effects—by the re-entry of this water into the hydrologic cycle.

7. As a class, evaulate both murals—origins and downstream. Identify, list, and discuss places in which the quality of the water in the water cycle may be affected by human activities.

8. Now, shift the emphasis to the amount of water that people typically use. On a Friday, hand out the "Water Use Worksheet Week 1," one for each student.

9. Ask students to keep track of how much water is used in their homes for seven days, from Saturday to Friday. Students may post the sheet on their refrigerator and have each family member help by putting a mark in the section designated after each water use. The miscellaneous section is for special uses not listed (filling a fish tank, bathing the dog). Students bring in their results on Monday.

10. On Monday, make a master chart on the board that summarizes total use in class's homes for the seven days. Brainstorm places where water might be conserved. Challenge each student to reduce use and invite his or her family to join in. On Friday, hand out "Water Use Worksheet Week 2" with the "Wise Water Use Tips" on the back (preferable; you can photocopy onto another page if necessary). Students will monitor use for another seven-day period (from Saturday to Friday) while using the wise water use tips. Students bring in their results on Monday.

11. On Monday, tabulate results from Week 2. Compare class results with Week 1. Was there a significant reduction in water use? Hold a classroom discussion on what was easy to change and what was harder.

Results and reflection

1. Students draw and label a flow chart tracing water in their community: from where it comes—to their homes—to where it goes after leaving their home.
2. Using the "Water Use Worksheet Week 1," have students total the number of gallons of water their families used in personal hygiene activities, home maintenance activities, and "other" activities. Have students create a chart or graph (for instance, a pie chart) to illustrate the three types of activities as a part of their family's total water usage. Ask students what type of activity used the most water? The least? How are these facts illustrated by their chart or graph? Repeat this activity with "Water Use Worksheet Week 2." Students compare the two charts for changes in their family's water use.
3. Once the results are tabulated, discuss how wildlife, habitat, and humans benefit from human water conservation. Discuss potential appropriateness and effectiveness of water conservation behaviors. Discuss ways to protect the quality of water we use. List and discuss actions that each of us can take to reduce or prevent pollutants from entering the hydrologic cycle.
4. Have students name three ways they could conserve water. Ask how much water could they conserve using each method for a year? How might wild animals be affected by their water conservation actions?
5. Ask students for examples of ways that water quality can be affected negatively by human use. Ask for examples of actions people can take to protect the quality of water.

Conclusions

The water cycle recycles Earth's water supply. Keeping water free of pollutants and using wise water conservation practices will keep our water supply usable for humans, plants, and wildlife. Students can make choices about the amount of water they use and what they put down the drain. The ocean is downstream from us all.

Extensions and applications

1. Locate your community's water source. Visit it on a field trip.
2. Have students monitor water use in the school, and identify ways to conserve water. Dripping faucets? Running toilets? Runoff from watering plants?
3. Take field trips to purification plants and treatment plants.
4. Students may create a poster campaign to raise the awareness in the school or community about water conservation and water quality.

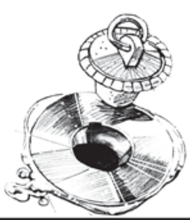
Adapted from

Alice in Waterland, ©2000, 1992, 1985. Council of Environmental Education. Reprinted with permission from *Project WILD Aquatic Activity Guide*. The complete Activity Guide may be obtained by attending a Project WILD workshop. For more information, contact the California Project WILD Aquatic Office at (916) 653-6132.

Further references:
California Dept. of Water Resources Website, materials for classrooms and poster are available. *www.owe.water.ca.gov/education*

Water Use Worksheet
How Much Water Does Your Household Use?

WEEK 1 What it takes	What you do	How many times? (~~||||~~ ||)	Total gallons
3 gallons	Flushing a toilet		
3 gal. (water left running) 1 gal. (water turned off)	Brushing teeth		
5 gal./min. (old showerhead) 2.5 gal./min. (new showerhead)	Shower (avg. shower length ____)		
40 gal. if full	Taking a Bath		
10 gal.	Washing Dishes		
40 gal.	Washing clothes		
40 gal.	Watering lawn		
40 gal.	Washing a car		
OTHER: estimate gallons used			



How Much Water Does Your Household Use?

WEEK 2 What it takes	What you do	How many times? (~~||||~~ ||)	Total gallons
2.5 gal. (with a ½ gal. bottle in tank)	Flushing a toilet		
3 gal. (water left running) 1 gal. (water turned off)	Brushing teeth		
5 gal./min. (old showerhead) 2.5 gal./min. (new showerhead)	Shower (avg. shower length ____)		
40 gal. if full/20 gal. if ½ full	Taking a Bath		
10 gal.	Washing Dishes		
40 gal.	Washing clothes		
40 gal.	Watering lawn		
0 gal. (carwsh that recycles water)	Washing a car		
OTHER: estimate gallons used			

The ultimate test of man's conscience may be his willingness to sacrifice something today for future generations whose words of thanks will not be heard.

–**Gaylord Nelson**
Former Governor of Wisconsin
Founder of Earth Day

Wise Water Use Tips

Shower
Get yourself wet in the shower, then turn the water off while you lather up. Turn it back on to rinse off. Reduces the number of minutes shower is on. Or, ask your parents to purchase a low-flow showerhead. Any new showerhead made in the U.S.A. will use a maximum of 2.5 gallons/minute.

Brushing your teeth
Turn the faucet on briefly to wet your brush, then turn it off until you're done brushing and ready to rinse. Uses less than 1 gallon.

Washing clothes
Wait to run the washing machine until you have a full load. This reduces the number of loads you need to do.

Washing dishes
Wait to run the dishwasher until you have a full load. This reduces the number of loads you need to do.

Toilet
If your toilet was made after 1992, it uses an average of only 1.6 gallons/flush. If your toilet is older, try placing a plastic bottle filled with water in the tank. This reduces the amount of water used for each flush by the amount of water in the bottle.

Bathtub
Fill the bath only halfway, saves 20 gallons.

Washing a car
Take your car to a carwash that recycles water. Saves 40 gallons and reduces water pollution.

Watering your garden
Water just once per week, deeply, in the early morning to reduce evaporation. Keep a bucket in the bathroom and kitchen for when you're waiting for water to warm up. Use to water plants. Encourage adults to plant native and drought-tolerant plants to reduce watering even further.

Cleaning house
To clean the driveway or patio, use a broom instead of the hose. Save water, get exercise!

Grade 5 Activity

Science skills

- Observing
- Predicting
- Hypothesizing
- Analyzing

Concepts

- Water flows through and connects watersheds.
- Wherever you are, you are in a watershed.

California Science Content Standards

Earth Science

3. Water on Earth moves between the oceans and land through the processes of evaporation and condensation. As a basis for understanding this concept, student will know:

3.a. Most of Earth's water is present as salt water in the oceans, which cover most of Earth's surface.

3.d. The amount of fresh water located in rivers, lakes, underground sources, and glaciers is limited and that its availability can be extended by recycling and decreasing the use of water.

3.e. Students know the origin of the water used by their local communities.

Objectives

Students will:

- Investigate drainage patterns.
- Observe how watersheds distinguish different land areas.
- Discover the origin of the water used in their local community.

Time to complete

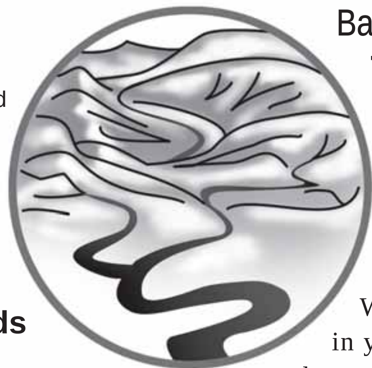
Two 50-minute periods. If making permanent watershed, allow at least three days for materials to dry before conducting experiments.

Mode of instruction

Small group model making followed by experiments and analyses.

Activity 5.3 Branching Out

Where does your water come from? Build a model watershed and predict where the water will travel across the land.



Background

The water cycle is the path water takes through its various states—vapor, liquid, and solid—as it moves through Earth's systems (oceans, atmosphere, ground water, streams, etc.). As we see a rushing stream or a river gushing during a major rainstorm, we may ask, Where does all this water come from? As we watch water flow down a street during a heavy rainstorm, we may ask, Where does all the water go? Answers may be found right in your own neighborhood! No matter how dry it looks, chances are there is water flowing far below your feet. Wherever you are, you are in a *watershed*, the land area from which surface runoff drains into a stream channel, lake, ocean, or other body of water.

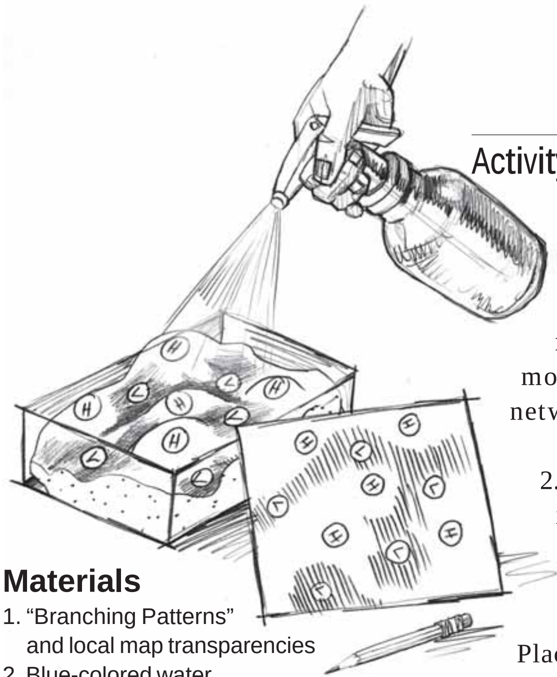
The pattern water makes as it flows through a watershed is familiar to students who have drawn pictures of trees or studied the nervous system. By investigating drainage patterns, we can better understand how watersheds distinguish different land areas.

When the ground is saturated or impermeable to water (when water cannot soak into the ground) during heavy rains or snowmelt, excess water flows over the surface of land as runoff. Eventually this water collects in channels such as streams. Watersheds are known by the major streams and rivers into which they drain.

Watersheds are separated from each other by areas of higher elevations called ridge lines or divides. Near the divide of a watershed, water channels are narrow and can contain fast-moving water. At lower elevations, the slope of the land decreases, causing water to flow more slowly. Eventually, water collects in a wide river that empties into a body of water, such as a lake or ocean.

From a bird's eye view, drainage patterns in a watershed resemble a network similar to the branching pattern of a tree. Tributaries, similar to twigs and small branches, flow into streams, the main branches of the tree. Like other branching patterns (e.g., road maps, veins in a leaf), the drainage pattern consists of smaller channels merging into larger ones.

Watersheds are either closed or open systems. In closed systems, such as Mono Lake in northeast California, water collects at a low point that lacks an outlet. The only way water leaves is by evaporation or seeping into the ground. Most watersheds are open—water collects in smaller drainage basins that overflow into outlet rivers and eventually empty into the sea.



Materials

1. “Branching Patterns” and local map transparencies
2. Blue-colored water
3. Spray bottles or sprinkling cans, one for each model
4. Drawing paper and pencil
5. Blue pencils
6. Tracing paper or blank transparency sheets
7. Photocopies of a local map showing rivers (watersheds also if available), one for each student
8. Overhead projector

Note: Students may build a temporary, simpler model, or a durable version that can be used for further experiments. Materials for both are listed here.

For both models

1. Five to ten rocks, ranging from 2 to 6 inches (5 to 15 cm) in height. If groups of students are making their own models, each group will need its own rocks.
2. Square or rectangular aluminum tray, large enough to hold rocks. A large disposable baking or turkey roasting pan will work.
3. Plastic wrap (thick plastic wrap from a grocery or butcher shop works best).

For temporary model

White scrap paper, newsprint, or butcher paper

For permanent model

Note: Allow extra time to make this model. Begin it at least three days before the experiments are to be conducted—the papier-mâché needs to dry overnight, and then the paint needs time to dry completely.

1. Papier-mâché materials (strips of newspaper dipped in a thick mixture of flour and water)
2. Water-resistant sealer and white paint (or white waterproof paint)

Activity

1. Ask students what they know about watersheds. Is there one near their home? (*Trick question: Wherever you live, you are in a watershed, even if that watershed is covered with asphalt.*) What is in a watershed? How can you tell one from another? Can you name a local watershed? Tell students they are going to build a model of a watershed to see how water flows through a branching network of drainages.

2. Depending on whether a temporary or more permanent model is being built, students will do the following:

Temporary model

Instruct students to select six rocks and wrap them with white scrap paper. Lay them in a square or rectangular aluminum tray. Place larger rocks near one end of the tray. Cover the paper-covered rocks with plastic wrap.

Permanent model

Instruct students to lay rocks in a square or rectangular aluminum tray, with larger rocks near one end. Snugly cover the rocks and exposed areas of the tray with plastic wrap. Apply strips of papier-mâché to cover the rocks. For a studier model, apply several layers of papier-mâché. When the mâché has dried, coat the model with white paint and waterproof sealant, or waterproof white paint.

3. Students will sketch a bird’s eye view of the model. They should mark points of higher elevations with “H”s and low spots with “L”s. To identify possible ridgelines, connect “H”s.

4. Tell students the model will soon experience a rainstorm. Where do they think water will flow and collect in the model? Have them sketch their prediction on their drawings. Indicate the crevices in their models and possible locations of watersheds.

5. Students will spray blue-colored water over the model and note where it flows. Water may need to be sprayed for several minutes to cause a continual flow. Assist students in identifying branching patterns as water from smaller channels merges into larger streams.

6. Students will use blue pencil to mark on their drawings the actual branching patterns of water. Some imagination and logic may be required. Ask them to confirm the locations of watersheds by noting where water has collected in the model.

7. Ask students to determine if smaller watersheds overflow into larger ones. Does all the water in the model eventually drain into one collection site (open watershed system)? Does the model contain several closed water systems (collection sites that lack an outlet)?

8. Students will place tracing paper or an overhead transparency over their drawings and draw the drainage patterns. Groups compare and contrast each other’s drawings. Discuss how the networks of smaller channels merge together to become larger.

Preparation

Collect materials, photocopy transparencies and maps, build models, and keep a space open in the room for the models to be worked on and displayed.

Outline

Before class:

1. Decide whether you will build the more durable and permanent watersheds or the lighter and more fragile temporary watersheds. Purchase or have students bring in appropriate materials (see list) based on this decision.
2. Have students bring in all other materials (rocks, blue pencils).
3. Photocopy map of the area around your school, with rivers and streams. One copy for each student.
4. Photocopy onto overhead transparency "Branching Patterns" sheet.

During class

1. Show overhead transparency of "Branching Patterns."
2. Arrange students into small groups of 3-4 students.
3. Using sample model making materials, illustrate how to make the model.
4. Distribute materials to each group.
5. Oversee model manufacturing (depending upon which model you choose, assembling the model will be completed in one day or over a series of days).
6. Allow students to proceed with experiments, roving from group to group to assist.
7. Whole class discussion on watersheds.

9. Hand out photocopied maps of local area with streams, rivers, and lakes. Students locate streams and rivers and draw a circle around land areas they think drain into the river.

10. Students pick one river on the map and follow its path in two directions (upstream and downstream). If the entire river is pictured, one direction should lead to the headwaters or source, and the other direction merge with another river or empty into a body of water.

Results and reflection

1. Students predict where water will flow and collect in watershed model, and write their predictions on a piece of paper.
2. Students test their predictions and use the results to confirm or modify their projected drainage patterns.
3. Students will compare the drainage pattern of watersheds to other branching networks.
4. Students write a story about or draw a map of drainage patterns in their watershed. Label mountains, rivers, streams, reservoirs, lakes.

Conclusions

Watersheds have a branching pattern that distributes water from rain and snow into streams, rivers, and lakes. Water moves from high to low areas, collecting in drainage basins. These drainage basins are the source of water for most of our communities.

Extensions and applications

1. If the model were a real land area, would the drainage patterns be the same thousands of years from now? Students should consider the effects of natural and human-introduced elements (e.g., landslides, floods, erosion, evaporation, water consumption by plants and animals, runoff from agricultural fields, droughts, dams). Have students write one page describing what the future watershed looks like.
2. Students may finish their models by painting landscapes and constructing scale models of trees, wetlands, and riparian areas. Introduce human influences, such as towns and roads.
3. As in the game "Pin the Tail on the Donkey," blindfold students and have them randomly touch a point on a map of California. Have students explain likely routes water would take in that area. Where is the closest large river? Lake? Ocean? Are there dams on the river?
4. Students may make a topographic map of their model. First, they totally waterproof the model. Next, they submerge it, one-half inch at a time, in water. At each increment, while viewing from above, they trace the water level onto a sheet of glass or clear plastic held over the model. Students can make elevation lines and draw the map true to scale.

Adapted from

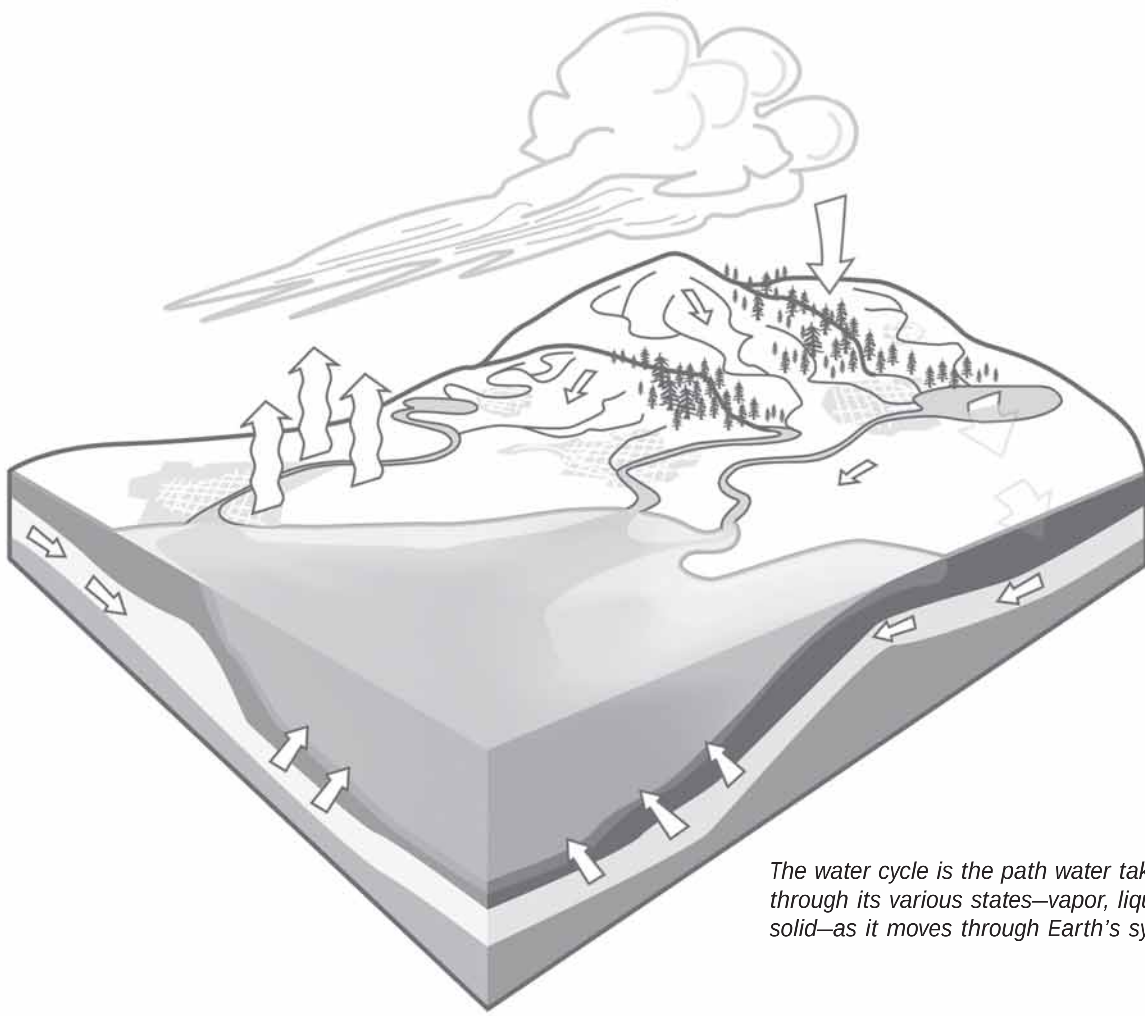
Branching Out is used with permission from Project WET/Montana State University from the *Project Wet Curriculum and Activity Guide.* For further information about Project WET (Water Education for Teachers), contact the national office at (406) 994-5392, or the California Project Wet, Water Education Foundation, (916) 444-6240, *www.wateredducation.org*

Other References

Project GLOBE. www.globe.gov

Branching Patterns

The Water Cycle



The water cycle is the path water takes through its various states–vapor, liquid, and solid–as it moves through Earth's systems.

Notes

Chapter 6
Powerful Forces Shape Our Coast

California is a coastal state, with the vast and powerful Pacific Ocean as a next-door neighbor. Our state has been formed by natural processes that change short term by the seasons, and long term over millions of years. Seismic forces, in addition to the forces of waves, wind, and water, shape our coast. These forces uplift coastal bluffs, erode cliffs and riverbanks, build dunes, and form beaches.

Coastal erosion and accretion have been shaping our coast for many thousands of years. The present day shape of the coast reflects thousands of years of sea level change, continental uplift and subsidence, landslides, earthquakes, and ocean waves. Interactions among these forces episodically accrete (add to) and erode the coastline, resulting in the spectacular beaches and cliffs that border much of coastal California. As sea level rises over time, water gets closer to the cliffs and they are battered by waves.

Our coast also changes over the seasons and the short term, from violent storms, periodic events such as El Niño, and random events such as tsunamis. Consequently, it is important to realize some geologic and oceanographic processes are constant, others are cyclical, some are intermittent, and some are random. Some operate rapidly and are easily observed, while others operate very slowly and cannot be measured except through a long period of continued observation.

New Words and Phrases

erosion; accretion; tsunami; coastal armoring; sea level; global warming; sea walls; groins; jetties; beach profiles; uplift; subsidence; landslides; longshore sand movement

California Coastal Commission Area of Critical Concern: Coastal Processes

Relevant California Science Content Standards, Grade 6: Earth Sciences 2. a, c

Coastal erosion is natural, but things people do alter it. People build seawalls to protect buildings built close to the ocean. Human barriers to erosion, such as seawalls and retaining walls, can protect what is behind (landward of) them, but do nothing to protect the beach. As waves interact with these structures, erosion may increase up and down the beach. Building dams on rivers reduces the amount of sand that reaches the coast, making for smaller beaches that may inadequately protect cliffs. We can increase erosion with the increased runoff caused by developing the coast. Climbing up and down the bluff face, disturbing sand dune vegetation, digging for fossils, or carving in cliffs also increases erosion.

Beach accretion (sand build-up on beaches) is also natural. Sand beaches form upcoast of headlands and points, in the protected portion of bays, along the seaward portion of sand dunes, and on the open coast where there are rivers to maintain a supply of new sand to the coast. Engineering structures such as groins and jetties can cause sand to build up on

Grade 6 Activities

These activities bring our dynamic coast to life. Students experience firsthand the natural and human made changes to the coast, and conduct experiments and calculations that help them visualize the impacts of erosion and sand movement.

Activity Goals

6.1. Beaches: Here Today, Gone Tomorrow?

Students will:

1. Know how to conduct a beach transect.
2. Have a basic knowledge of beach substrate, geologic formations, erosion, and methods of beach monitoring.

6.2. Shifting Sands

Students will:

1. Know how waves move sand and cause erosion.
2. Understand how barriers like groins and jetties alter coastal processes.

6.3. Rollin' Along the Sand Highway

Students will:

1. Use harbor dredging records to calculate the amount of sand that moves along California's coast.
2. Understand human impacts on sand movement and beach size.

the upcoast side. Breakwaters can provide a protected harbor area landward of the structure, but also can trap sand and build up beach areas. Structures such as groins and jetties will usually produce accretion (more sand added to the beach) in one area but may produce erosion in another. Beach nourishment, which takes sand from offshore deposits or from inland reservoirs and dams, can add new sand to beaches and provide for beach accretion without causing erosion elsewhere.

To sustain California's open coast, we must learn to live with the forces that shape the coast. To do this successfully and safely, we must understand how coastal processes work, set development back from the bluffs, and reduce human impacts to beaches and bluffs.

Coastal accretion and erosion cannot be studied alone, as there are many interrelated processes that operate within and outside the coastal zone. A study of the coast can be an entryway into a host of different areas in Earth sciences, including global climatic change, fluctuations in beach size, sea level fluctuations, faulting, earthquakes, tides, and more.

Natural forces on the coast affect erosion:

- Number one cause is the rise in sea level, a natural phenomena that is accelerated by human influence (see below).
- Wave action and resulting sediment transport.
- Runoff from land.
- Storm events and irregular events (El Niño, La Niña, tsunamis).
- Combination of big waves with high tides.

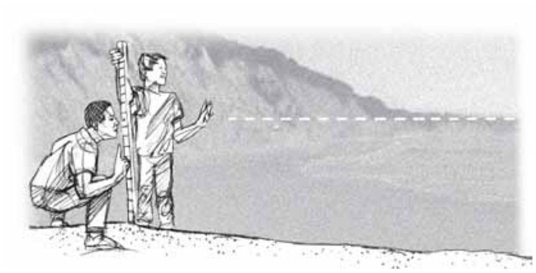
Human forces on the coast contribute to erosion:

- Damming rivers reduces amount of sand that reaches the coast; smaller beaches offer less protection to coastal bluffs.
- Coastal development that increases impermeable surface and changes runoff patterns may cause bluffs to be less resistant to erosion.
- The rise in sea level caused by global warming from the accumulation of greenhouse gases in the atmosphere.
- Armoring the coast by building barriers to protect naturally eroding cliffs may cause increased erosion of beaches on either side of the barrier.
- Climbing up and down cliffs, trampling sand dune plants, digging out fossils from cliffs, disturbing cliffs in general.

Natural and human forces contribute to accretion:

- Storms and high flood events may add sand to beaches.
- Harbor dredging can add sand to nearby beaches when dredged sand is dumped on these beaches.
- Beach nourishment projects, in which sand is transported to beaches from elsewhere.

Grade 6 Activity



Science skills

- Measuring
- Calculating
- Observing
- Hypothesizing
- Recording

Concepts

- Beaches change with the seasons and over time.
- Changes are due to waves, erosion, and discharge of sediments from rivers.
- Beach profiles can be used to document how a beach changes.

California Science Content Standards

Earth Sciences

2. Topography is reshaped by weathering of rock and soil and by the transportation and deposition of sediment. As the basis for understanding this concept:

2.a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.

2.c. Students know beaches are dynamic systems in which the sand is supplied by rivers and moved along the coast by the action of waves.

Objectives

Students will:

1. Measure the shape or profile of a beach.
2. Understand that beach profiling is a valuable method of monitoring the erosion and accretion patterns of beaches.
3. Have a basic awareness of beach shape, geologic formations, erosion, and methods of beach monitoring.
4. Understand why beaches change with the seasons, and where sand goes in winter.

Activity 6.1
Beaches: Here Today, Gone Tomorrow?

The ocean is constantly in motion. Every day, the combinations of currents, tides, and waves move and shape our coastline. Find out how these forces work their magic through measuring a beach profile. This activity requires a trip to the beach, but Step 1 may be done on its own in the classroom.

Background

Did you ever go back to a beach in the winter that you had visited in the summer? Chances are, it was a very different beach! The wide, white sand beach you were expecting may have turned into a narrow, steep, rocky platform. Or, it may even be underwater. Not to worry, beaches change naturally between the summer and winter months. In general, beaches get wider in the summer months, and narrower in the winter months. Sand is delivered to the beaches in the winter through storm runoff and increased flow of water (and sediments) from rivers. At the same time, the big waves pull sand off the beaches and deposit it just offshore so the beach gets narrower. Much of the sand is stored just offshore in underwater sandbars, and some of the sand moves downcoast as it gets carried by longshore currents that are generated by breaking waves. In the summer months, the smaller waves pick up sand from the underwater sandbars and move it back up onto the beach.

Changes from year to year, especially if one of those years is an El Niño year, can be quite dramatic. Big winter waves occurring simultaneously with very high tides have been responsible for massive amounts of property damage costing millions of dollars in coastal areas.

The cyclical interaction of winter storms bringing sediment to our coast, and summer waves washing the sand up onto the beaches, provide a perfect natural venue for winter adventure and summer fun.

A single line transect is an effective way to study beach shape, beach activity, and geologic formations. This activity allows students to measure the natural changes that occur on our beaches, and graphically represent the natural forces that shape our coast.

Time to complete

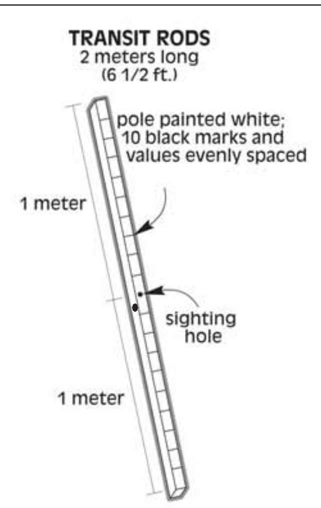
Classroom discussion: 0.5 hour.
Field trip: time on beach, approximately 1.5 hours. Analyzing and graphing data: 0.5 hour.

Mode of instruction

Classroom discussion followed by small group activity on field trip.

Activity

1. On overhead projector, show “Beaches: Here Today, Gone Tomorrow?” transparency. Lead a whole class discussion on what students know about how beaches are formed. From where does the sand on beaches come? Do beaches look the same year round? Why do some beaches have fine, white sand, while others have coarse sand? Where do beaches go in winter?



How to Make Transit Rods and Line

Make one pair of transit rods per group; the two rods must be made identical to each other. Each rod is approximately 5 cm (two inches) square and 2 meters (six and a half feet) long. You may use a single 2” x 4” cut in half lengthwise—you can have this cut at a lumber store. A hole (1/2” diameter) should be drilled through the center of each pole for use as a sighting device; it’s not necessary, but simplifies the measuring process. You can have them drill the hole at the lumber store, also. Poles should be painted white and marked in decimeters from the center using black paint or permanent marker, with minus values marked above the hole and plus values marked below the hole. Put marks on same side of rod as the hole.

To make the line, it’s preferable to use polyethylene, as it is light, doesn’t stretch much, and may be purchased in white or yellow. Twine also works. Mark the line in increments of one meter each, using a permanent marker or by wrapping it with black electrical tape.

Materials

For whole class:

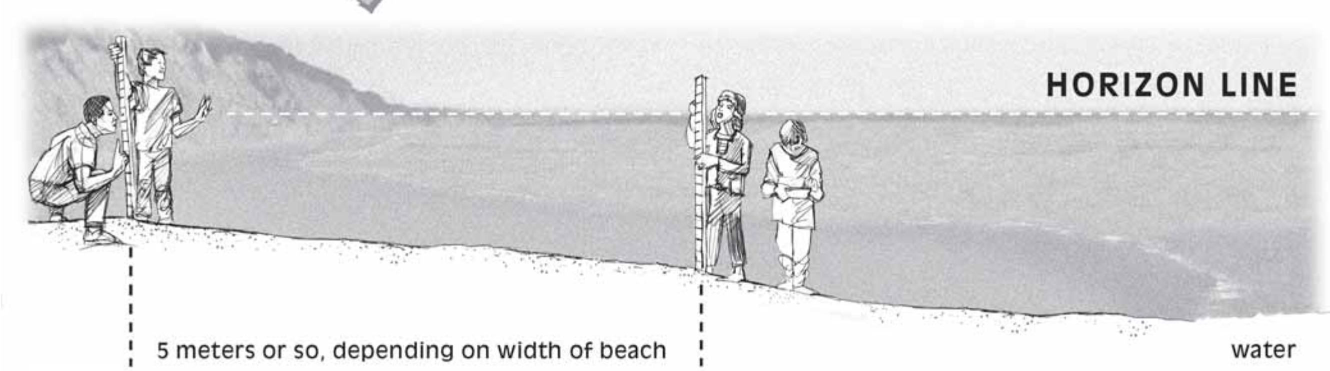
1. Local tide table
2. Spreadsheet with graphing capability (optional)
3. Camera (optional)
4. Overhead projector

For each group (4-6 students):

1. Two transit rods
2. Line: heavy twine or light rope that will not stretch, about 10-15 meters
3. Additional line and a line level, inexpensive and available at hardware stores (optional)
4. Sight marker (old ping pong paddle, a book, or a student)
5. Clip board with “Beach Profiling” worksheet
6. Graph paper

2. Ideally, first conduct the beach profiling activity on a slope on your school grounds. If this isn’t possible, you will need to explain what the activity is and how to measure beach profiles before you leave the classroom for your fieldtrip. Review the “Beach Profiling Worksheet” and discuss how to collect data.

3. **Beach Profiling Activity.** Once you are at the site to be profiled (initial dry run on school grounds, or real activity at beach), divide the class into small groups (4-6 students). Hand out a set of materials to each group. Have each group establish a “permanent benchmark,” a permanent reference point or starting point (if you have access to a Global Positioning System [GPS], this is ideal). Your permanent benchmark can be a house, tree, permanently attached bench, massive rock, etc. Something that doesn’t move. Groups should be positioned no closer than 50 feet up and down the beach from each other.



Preparation

Locate a beach within an easy field trip distance. This activity can be done at the same time as a tide pool field trip, or a beach cleanup day.

To reduce preparation time, make only two sets of transit rods and line, and have student groups rotate from tide pooling or beach cleanup to beach profiling (you will need another adult assistant to monitor groups at the alternate activity).

If possible, choose a beach that you know changes drastically between winter and summer. For the most dramatic experience, do this activity twice in a school year; once near summer or fall (June, September or October) and once in mid-winter (January or February). Do yearly at the same beach, and keep records for students to compare their profiles with profiles from previous years. Photographs make a nice graphic complement.

Outline

Before class

1. Weeks before: arrange field trip details, assemble materials, and make transit rods.
2. Photocopy data recording sheets.
3. The day before your field trip, try this activity as a teacher-led demonstration at your school. You will need three assistants. *Note: you must have a large, gradual sloping area in which to work, and a clear horizon.*

During class

1. Arrive at field trip location.
2. Divide class into groups of four to six students (four to five groups total). Have students in groups divide themselves into transit rod holders and recorders (minimum two of each).
3. Pass out materials, one set to each group (clip board, transit rods and line, data sheet). Or, if doing tide pooling or beach cleanup at same time, assign tasks accordingly.
4. Review method of collecting beach profile data and how to record it.
5. Assist groups with finding a starting point.
6. Circulate among groups to assist with questions during profiling exercise.
7. Regroup at end to compare experiences.

4. Direct students in measuring the beach transect.
   a. Students record benchmark location, tide level, evidence of plant or animal material, and sand or soil type on worksheet.
   b. Set the first transit rod at the starting point. Take the second transit and move it to a location closer to the water, following a line perpendicular to the water line. You may use an even increment of distance (such as five meters) but it is best to move to the next point of change in elevation patterns (such as the edge of a berm or center of a depression), but rarely more than 10 meters. Use the line to measure the distance, keeping the transit vertical and the line perpendicular to the transits. The person at the first transit sights through the hole to the second transit and reads the value on the second transit where the horizon appears on the transit. This is a level line. If the person cannot make out the numbers due to distance, the person on the second transit can be guided to move their finger up or down until they point to the mark on the transit. Record the number on the data sheet.
   c. Following the first measurement, move the first rod transit to the new location closer to the water. Keep the second transit rod in place as it will now serve the same role as the first transit. Place the marker at the site of the first transit as a guide to allow the profile to follow a straight line. Repeat this process, leapfrogging over each transit rod for subsequent measurements.
   d. <u>If a horizon is not available</u> (i.e, it is a cloudy day), use the line level: use a separate line with the level. One end of this line must be at the site of the first transit with the line pulled taut between the two transit rods. The line level is hung on the line at the center between the two transit rods, and the line is moved up and down on the second transit rod until the level reads as level. Use another person to do this. When the line is level, its position at the second transit marks the elevation change. Do not use large increments of distance if you use the line level; five meters is optimum.
   e. Continue measuring and recording elevations until you measure to sea level (the glistening part of the sand when the waves retreat). This is the end of the beach profile recording exercise.

5. Optional: Take pictures of the beach from several angles for later reference or for posting on the Internet (see Ext. #2).

6. Back in class, students can either enter their data into a spreadsheet program with graphing capability, or plot their data points on graph paper. The values they measure will generally be negative values from the starting point. These may be adjusted to reflect your own needs in terms of the graphs you wish to produce or how you wish to view them. For example, if the starting point is referred to as “0” and sea level appears at –53 decimeters and a distance of 120 meters, you may want to change them to represent sea level as “0” and your actual starting point as an elevation of 53 decimeters at a distance of 120 meters from sea level. Data kept on a spreadsheet can more easily be compared with previous years’ results.

Results and reflection

1. Do students understand the profiling procedure, and are they aware of what they measured? Conduct a whole class discussion on their profiling experience.
2. Do students understand how the beach profile will change over the year, and the physical forces that influence the beach profile? Have students draw an illustration of a beach during the summer and winter.
3. Students will create a graph that shows the beach profile using the data they collected.
4. Scientists have found that more coastal erosion occurs in episodic events, such as an El Niño or a big storm, than the erosion that occurs slowly over time. In a big storm year, waves are often stronger than usual storm waves, and if they coincide with high tides, the effects can be devastating. In a classroom discussion, have students picture two different beaches: a normally narrow summer beach, say one downcoast from a rocky point, and a normally wide beach. What would be the effect of large storm waves on structures that are built close to the sand in each of these locations?
5. What do your students think of the process of sand mining (trucking beach sand away from the beach to be used elsewhere)? What about beach nourishment (bringing in sand from other places to replace sand lost due to wave erosion, or on beaches that are not normally wide)? Or how about dredging (pumping the sand from offshore back to the beach). How do these activities affect the beaches? How about the beaches on either side of the beach that is being mined, nourished, or dredged—how are they affected? Conduct a classroom discussion on the pros and cons of artificially moving sand from one place to another.

Conclusions

California's beaches are constantly being shaped and sculpted by natural forces whose origins can be thousands of miles from our coast. Understanding the seasonal and episodic processes that form our beaches leads to greater understanding of the potential hazards involved with living on the coast.

Extensions and applications

1. Carefully measured profiles may be recreated on cardboard or firm stock, cut out, and used to create a physical model of the beach. Find local information about the substrate rock material to incorporate into your model. Use samples of the different types of sand (from coarse gravel to fine sand or shells) found at your beach. If possible, locate historic aerial photographs of your beach area and look at the changes over time. Has it become smaller or larger? How has the population changed in the area of your beach over the same time? Any new dams, breakwaters, jetties, or groins?
2. The California Coastal Commission's Public Education Program may be posting profile data and photographs at *www.coastforyou.org*.
Call (800) Coast-4u for information.

Adapted from

Rumpp, George W. and Phyllis E. *Seastar: Beach Profile Project.* *http://mciunix.mciu.k12.pa.us/~seastar/*
Activity adapted from The Maury Project, American Meteorological Society.

Beaches: Here Today, Gone Tomorrow?

Which of these images are summer beaches? Which are winter beaches?
What are some of the differences between the two beaches?

Beach Profiling Worksheet

Beach location:

Date:

Time:

Tide status:

Other observations (beach or sand type such as fine sand, cobbles, gravel; near river or harbor; steep drop-off or wide gently sloping beach, etc.):

	Change of elevation	Cumulative change in elevation	Distance from last measurement	Cumulative Distance
Beginning elevation	0	0	0	0
First measure				
Second measure				
Third measure				
Fourth measure				
Fifth measure				
Sixth measure				
Seventh measure				

Draw a rough diagram of your beach profile here:

Grade 6 Activity

Science skills
- Hypothesizing
- Experimenting
- Observing
- Deducting

Concepts
- Currents, waves, and wind move sand along the coast of California.
- Human-built structures alter the natural movement of sand along beaches.

California Science Content Standards
2. Topography is reshaped by weathering of rock and soil and by the transportation and deposition of sediment. As the basis for understanding this concept:
2.a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.
2.c. Students know beaches are dynamic systems in which the sand is supplied by rivers and moved along the coast by the action of waves.

Objectives
Students will:
1. Describe the forces that naturally shape California's beaches.
2. List the benefits and risks of human-made structures that alter coastal bluffs and beaches.

Time to complete
One hour 15 minutes

Activity 6.2 Shifting Sands

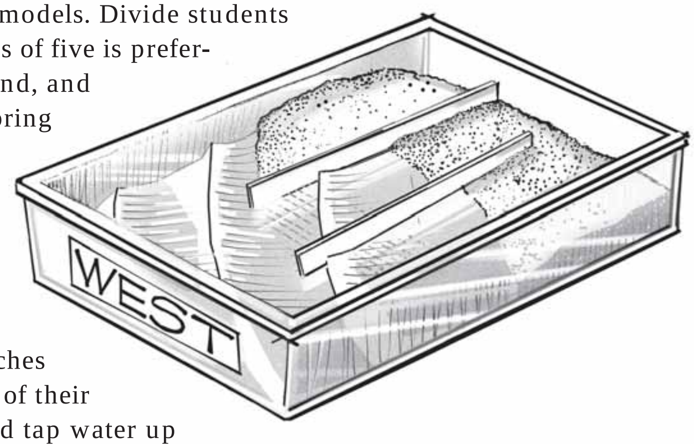
The ocean is constantly in motion, and nearshore currents carry sand and sediment along with them. Structures we build to protect the coast from erosion can change the shapes of beaches, for better or for worse!

Activity

1. Have students read background material from "Background and Model Instructions" worksheet (allow 10 minutes or so).

2. Lead whole class discussion on beach erosion, cliff erosion, and the protection of beachfront property. Describe the processes that create beaches. (*Wind, waves, currents bring sand to beaches; currents and waves move sand along the coast*). What types of structures do people build to protect their coastal property? (*Groins, rip-rap, seawalls.*) What happens when you disrupt the natural flow of sand along our coast? (*Some beaches are built up, while others get smaller. Smaller beaches increase the risk of erosion of coastal cliffs and bluffs.*)

3. Following instructions on worksheet, guide students in building the models. Divide students into small groups (groups of five is preferable). Distribute pans, sand, and rulers. Students should bring a pencil and unlined paper to their group. Students use tape to label the shorter sides of the pan "East" and "West." Students pour up to 4 inches of sand into the east end of their pans, and then gently add tap water up to 2 inches deep on the west end of the pan.



4. Students fold their paper into fourths. Using one section labeled *Diagram #1*, students draw their experimental models.

5. Student #1 uses a ruler to create a gentle wave action in the pan, in a general west-to-east movement.

6. Each student draws how the model appears after wave action (label it *Diagram #2*). What are the effects of erosion? How has the coastline changed as a result of the wave action?

7. Student #2 positions the sand in its original model configuration. Student #3 sets two to three rulers on-edge into the sand lengthwise about 4 inches apart, representing groins. Student #4 uses a ruler to create the same gentle west-to-east wave movement. What happens in between the groins? What happens to the shoreline? Students draw *Diagram #3*. Now, Student #5 makes waves coming from the northwest.

Mode of instruction

Whole class discussion followed by small group hands-on activity.

Materials

1. 12-inch rulers (4 for each group)
2. Rectangular pans or plastic bins (9” or 12” deep, more than 12” long, one for each group)
3. All-purpose sand (79 lb. Bag)
4. Tap water
5. Overhead projector
6. Photocopies of “Shifting Sands Background and Model Instructions” worksheet, one per student
7. Overhead transparency, “Groins and Jetties”

Preparation

Collect materials for beach models. Photocopy overhead transparency “Groins and Jetties,” and “Shifting Sands Background and Model Instructions” worksheet.

Outline

Before class

1. Gather materials for the number of groups (five students per group).
2. Photocopy onto overhead transparency “Groins and Jetties.” Photocopy “Shifting Sands Background and Model Instructions,” one for each student (two pages).
3. Prepare a beach model on your own to determine how much sand needs to go into the pans you have, and experiment with making waves. Prepackage the appropriate amount of sand into sealable plastic bags—about two cups, depending on size of pan.

During class

1. Lead whole class discussion on beach erosion and the effects of groins, jetties, and cliff protection structures.
2. Divide class into small groups (five students per group).
3. Distribute materials to each group. Describe how to label the model and how to create waves.
4. Have students illustrate their results.
5. Display and discuss overhead transparency.

Do beaches in between the groins change? Students draw *Diagram #4* to indicate how the beaches look after completing this wave action.

Results and reflection

1. Display the overhead transparency of the beach images with groins and jetties. Ask students what they think are the forces at work here. (*Currents, waves, actions of waves hitting a vertical surface, water carrying sand in suspension*).
2. Compare and contrast jetties with groins. *(Groins protect beaches from getting washed away by waves and currents. Jetties help to protect inlets and harbors from filling up with sand moving along shore. Both jetties and groins can be constructed of rock. Both affect beaches to either side.)*
3. Discuss social and political aspects of building beach protective structures on public and private land. What happens if a beachfront homeowner wants her or his beach to be larger, because she or he is concerned the home is threatened by waves, and builds a groin to nourish the beach? The homeowner’s property is located north of a public beach, and the longshore current goes north to south. What will happen to the homeowner’s beach? What will happen to the public beach? Should he or she be allowed to build the groin? Who will be responsible for the loss of the multi-million dollar home if the groin is not built and the waves destroy the home and property? How could this situation have been prevented? *Note: in most cases, a California homeowner would not be permitted to construct such a groin.*

Conclusions

Currents, waves, and wind determine movement of sand along our coast. Structures we make to protect beaches may have unintended effects. Living on the coast requires cooperation and compromise.

Extensions and applications

Hold a classroom discussion or have students write research papers on the following topics.

• What are the effects on the coast due to the armoring of coastal cliffs that normally would be eroding?

• Rules, regulations, and laws govern the construction of groins, jetties, and concrete cliff barriers. How can we balance public safety and recreation needs with needs of private property owners?

• What are the benefits and risks of building on coastal cliffs and bluffs or beaches? How can we allow the natural forces of accretion and erosion to occur with minimum disturbance to human-made structures?

Adapted from

Erosion Creates a Change in the Landscape, from Consortium for Oceanographic Activities for Students and Teachers (COAST). Walker, Sharon H. and Kimberly Damon-Randall (Senior Editors) and Howard D. Walters (Associate Editor). 1998. Oceanography and Coastal Processes Resource Guide. Institute of Marine Sciences, J.L. Scott Marine Education Center and Aquarium, administered by The University of Southern Mississippi, Biloxi, Mississippi.

Additional resources
www.wsspc.org/tsunami/CA/CA_survive.html
www.epa.gov/owow/estuaries/coastlines/dec99/lossmaui.html

Shifting Sands: Groins and Jetties

Jetties are built to protect the entrance channel to a harbor so boats can enter and leave safely, as well as to stabilize the entrance. In California, beaches upcoast of jetties are usually larger than beaches downcoast of them. Why?

Most piers are built on pilings, large poles sunk into sediment or rock underwater. Most piers allow sand to flow underneath them; the pier in the middle of this photograph does not affect the flow of sand. However, the solid groin at the end of the sandy beach does.

The scalloped shape of the beaches shown in this image from southern California reflects the result of many groins built to protect sandy beaches.

What happens to sea cliffs when protective sand beaches aren't present?

Shifting Sands
Background and Model Instructions

Glossary

Seawall: a structure built on a beach, often made of concrete, parallel to shoreline, designed to protect buildings from the action of waves.
Revetment or rip-rap: A structure consisting of large rocks or other materials stacked in front of an eroding cliff, dunes, or structures to protect from wave attack.
Groin: A structure built perpendicular to the shoreline designed to trap sand moving along the shore due to the longshore current. A groin or group of groins usually extend to the end of the surf zone and are used primarily to replenish or stabilize beaches.
Jetty: Structures built in pairs that extend further into the ocean than a groin, to stabilize a navigation channel and keep the water calm for harbor entrances. The construction of both groins and jetties severely affects the flow of sand moved by the longshore current, depriving downstream beaches of sand.
Beach nourishment (replenishment): the process of moving sand from the offshore continental shelf or inland areas and depositing it onto the beach. Sand is dredged from the offshore shelf, often a mile or so from shore, and is loaded onto a barge which carries it close to the shore. The sand is sprayed onto a beach with the intent of widening the beach and increasing its height. The process of beach nourishment can be expensive, and it works best when the sand will stay in place for a long time. In some areas, winter storms have removed the sand added by the nourishment process within a single year.

Background

The ocean is in constant motion, fueled by currents, winds, tides, and waves. Every time you visit California's coast, you witness the effects of the powerful forces of ocean waves and currents (whether or not you can see them at the time). Currents usually can't be seen from the surface, but you can see waves as they break on the beaches, cliffs, or just offshore over submerged reefs. The word "wave" is used to describe an actual swell of water, as well as energy that moves through water.

Tsunamis. Waves can be caused by wind, undersea volcanic eruptions, or earthquakes, though most waves are caused by wind. Those caused by volcanic activity or earthquakes are called "tsunamis." A tsunami is a series of sea waves most commonly caused by an earthquake beneath the sea floor. In the open ocean, tsunami waves travel at speeds of up to 600 miles per hour. As the waves enter shallow water, they increase in height. The waves can kill and injure people and cause great property damage where they come ashore. The first wave is often not the largest; successive waves may be spaced many minutes apart and continue arriving for a number of hours.
Since 1812, the California coast has had 14 tsunamis with wave heights higher than three feet; six of these were destructive. The worst tsunami resulted from the 1964 Alaskan earthquake—it caused twelve deaths and at least $17 million in damages in northern California. Evidence suggests that large earthquakes capable of producing large tsunamis recur every two or three hundred years (California OES Earthquake Program, Earthquake Education Center, Humboldt State University). For information on what to do in case of tsunami, check this web site: *www.wsspc.org/tsunami/CA/CA_survive.html*

Surface Waves and Currents. Though both are powered by wind, waves and currents are different from each other. Waves transfer energy across the ocean surface from one part of the ocean to another. Surface currents are powered by the frictional drag of the wind on the ocean's surface, can be swift, sustained, and river-like, and are responsible for mixing water and transporting sediments and nutrients long distances. Surface currents are quite regular, and are formed in conjunction with major global wind patterns, whereas surface wave direction and velocity are affected by changing winds during storms and vary widely. As waves transfer the energy to the sea surface, the ocean water moves up and down, like a float bobbing on the water. The stronger and longer the duration of the wind, and the greater the distance over which it blows, the larger the waves. When a wave enters shallow water, it starts to feel the ocean floor and the lower part of the wave slows down while the upper part continues until it topples over. This is when it "breaks" on the beach. Breaking waves (or "breakers") also stir up sand and move it onto the beach.

Erosion, Transport, and Deposition. Currents and waves also move sediments along the shoreline. Removal of the sediments is called *erosion*. Movement of the sediment is called *transport*. When the sediments settle out on a beach, it is called *deposition*. During storms, waves and currents have more energy and more sand is removed. *Coastal erosion* is a natural process that occurs as cliff, bluff, or beach erosion. Coastal erosion is a fact of living on the coast, though many people (usually home and business owners who have valuable ocean front property) see it as a problem that must be contended with. Deposition causes some harbors to be filled with sand, and they then must be dredged regularly.

Building Beaches. Coastal engineers can "build" the size of their beach by constructing groins. An unfortunate side effect of jetties and groins happens on the beaches downcurrent of the structures. As the water moves with the longshore current, it carries sand with it. The water and sand hit the side of the groin, and the sand builds up on the beach that is upcoast of the jetty or groin. But, this means that the beach on the other side of the jetty or groin gets less sand, as the sand is stopped by the groin. What property owners do on their property can affect beachside property nearby and even public beaches.

Building a Beach Model

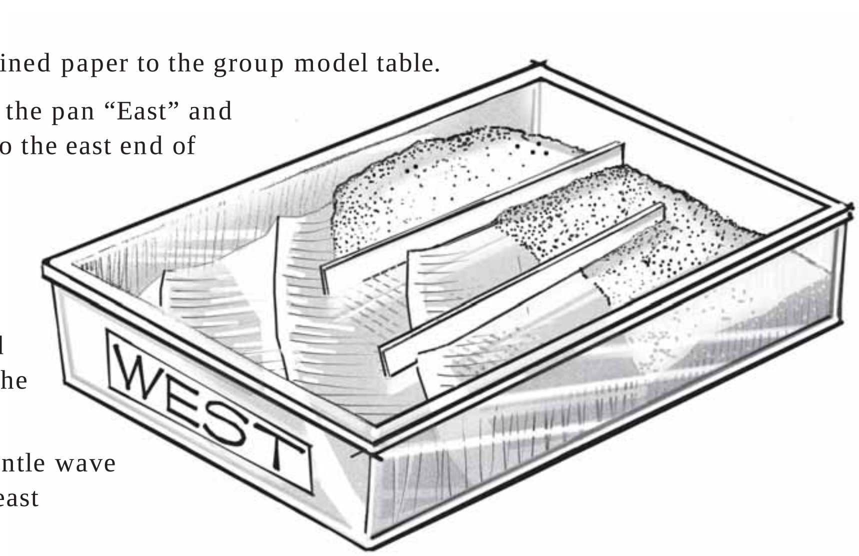
1. Each student brings a pencil and unlined paper to the group model table.

2. Using tape, label the shorter sides of the pan "East" and "West." Pour up to 4 inches of sand into the east end of the pans.

3. Gently add tap water up to 2 inches deep on the west end of the pan.

4. Fold your paper into fourths. Draw experimental model on one section and label it *Diagram #1* (use one-fourth of the paper).

5. Student #1 uses a ruler to create a gentle wave action in the pan, in a general west-to-east movement.



6. All students draw how the model appears after wave action (*Diagram #2*). What are the effects of erosion? How has the coastline changed?

7. Student #2 positions the sand to its original model configuration. Student #3 sets two to three rulers on-edge into the sand lengthwise about 4 inches apart, representing groins. Student #4 uses a ruler to create the same gentle west-to-east wave movement. What happens in between the groins? What happens to the shoreline? Draw *Diagram #3*. Now, Student #5 makes waves coming from the northwest. Do the beaches in between the groins change? All students draw *Diagram #4* to indicate how the beaches look after completing this wave action.

Grade 6 Activity

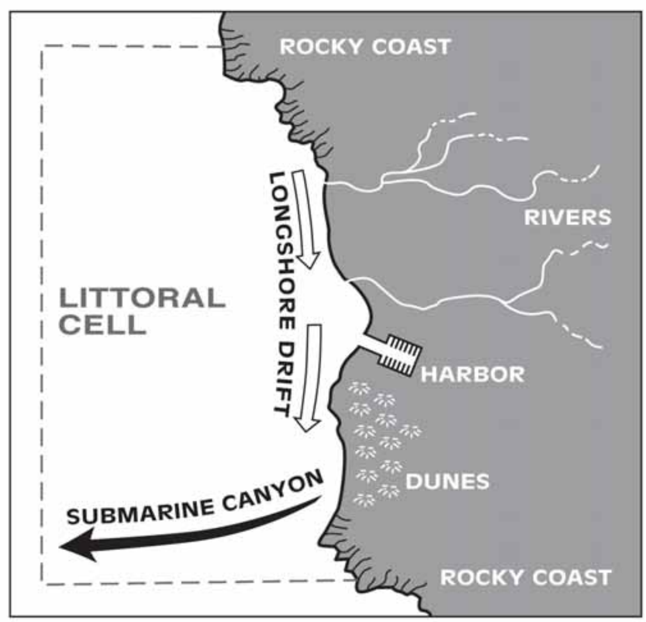
Activity 6.3
Rollin' Down the Sand Highway

Did you know there is a highway carrying truckloads of sand down our coast? You can't see it—it's underwater!

Background

Most everybody loves the beach and the sand between their toes. Beaches are an invaluable social, economic, and cultural resource in California. Southern California's beaches are the most popular recreation destination in the state, bringing tourists from all over the world. The sand for these beaches comes primarily from rivers, and is moved down the coast from north to south by longshore currents in most areas. What happens to this sand directly impacts the size of the beaches both seasonally and over a period of years. Understanding how and where sand moves helps us recognize the changes and impacts of the coastal harbors and structures we build along the coast.

California's coast can be separated into discrete coastal compartments termed *littoral cells* (the littoral zone is the region of shallow water along the shore of a body of water). A littoral cell is a self-contained system that may be bounded by rocky headlands or by a submarine canyon that intercepts the sand as it moves along the coast. Sand, supplied by rivers (80 to 90 percent) and bluff erosion (10 to 20 percent), moves in the system by waves and currents. Waves move sand onshore and offshore, and the longshore current moves sand along the coast.



Most of the sand is delivered to the coast by rivers during winter storms. Once it arrives at the coast, large waves wash ashore and drag the sand seaward where it is deposited in nearshore underwater sandbars (like a deposit in a sand bank!). In the summer, milder waves slowly move the sand that has been stored in the sandbanks back up to the dry beach (a transfer in the bank from the offshore account to the onshore account). Many beaches become narrow in the winter then recover their original width in the summer because of this sand banking system.

The predominant direction of longshore sand movement in California is from north to south. An incredible amount of sand is transported

Science skills

- Data collecting
- Analyzing
- Hypothesizing

Concepts

- Truckloads of sand are moving along California's coast every hour of every day, driven by currents and waves.
- Human constructions along the coast affect the longshore movement of sand, and can cause beaches to grow or shrink.
- The coast of California is composed of a series of littoral cells that affect the distribution of sand along the coast.

California Science Content Standards

Earth Science

2. Topography is reshaped by weathering of rock and soil and by the transportation and deposition of sediment. As the basis for understanding this concept:

2.a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.

2.c. Students know beaches are dynamic systems in which the sand is supplied by rivers and moved along the coast by the action of waves.

California Mathematics Content Standards

Number Sense

1.2. Interpret and use ratios in different contexts (e.g., batting averages, miles per hour) to show the relative sizes of two quantities, using appropriate notations (*a*/*b, a* to *b*, *a*:*b*).

Algebra and Functions

2.0. Students analyze and use tables, graphs, and rules to solve problems involving rates and proportions:

2.2. Demonstrate an understanding that *rate* is a measure of one quantity per unit value of another quantity.

2.3. Solve problems involving rates, average speed, distance, and time.

Objectives

Students will:

1. Measure the amount of sand that moves down California's coast.
2. Understand human impacts on sand movement and beach size.

Time to complete

One class period

Mode of instruction

Video, followed by whole class discussion. Students fill out worksheet with calculations, with a whole class discussion wrap up.

Materials

1. Video—*Beach: A River of Sand* (you may borrow it from the California Coastal Commission, *www.coastforyou.org, 800-Coast-4u*)
2. Overhead transparency of "Harbor Breakwaters and Jetties" and "Littoral Cell"
3. Overhead transparency of map of California, or map on wall
4. "Sand Highway" worksheet and "Harbor Dredging Data" table, one per student
5. Overhead projector

Preparation

Order video from Coastal Commission 2-3 weeks in advance of class. Read background material, photocopy overhead transparencies and worksheets.

underwater and along the beach face by longshore currents. Much of this sand ends up in submarine canyons (in which case the sand is gone from the coast forever because it is too deep to be brought up by small waves). Large quantities of sand are also carried by winter waves into harbors. This creates a big problem for the harbors that must be kept at a depth so boats can go in and out. Many harbors maintain an adequate depth by periodically dredging sand, a costly necessity. A few natural harbors in California do not need to be dredged: Bodega, Moss Landing, and Newport, for example. Moss Landing and Newport are between or at the upcoast end of littoral cells, and Bodega has a strong enough tidal flow to maintain an entrance channel. Crescent City, Monterey, Redondo-King, and Dana Point are successful constructed harbors that need little dredging because they are at the beginning of a littoral cell, or south of a submarine canyon.

A delicate balance exists between sand supplies, transport, and losses. Alterations to the system affect this balance. Coastal streams and bluffs, the two main natural sources of sand for our beaches, have been impacted by development in coastal watersheds. Dams and debris basins, in-stream sand and gravel extraction, and streambank and bed channelization have also reduced the sand supplies, particularly in highly urbanized southern California. Coastal armor designed to protect bluff-top coastal structures prevents the sand that would naturally erode from the bluff from reaching the beach.

Activity

1. Ask students, "Did you know that sand travels down the coast of California every day? Have you seen this sand travel? Why not?" Get a prediction from students of how much sand moves along our coast each day.

2. Watch the video *Beach: A River of Sand* with your class. Discuss the video with students; review how the coast is divided into discrete littoral cells with inputs and sinks. Project the transparency of littoral cells on the overhead projector. Tell them that within many of these littoral cells there are harbors that are regularly dredged to keep them deep enough for boats to enter. Without dredging, these harbors would eventually fill up with sand. Lucky for us, since it's because these harbors are dredged that we have a way to estimate exactly how much sand travels down the coast! We can measure the amount of sand that gets dredged out of the harbors—as long as the harbor is north of a submarine canyon or sink, that is. (If it is south of a sink, it may not need dredging—why not?)

3. Hand out a copy of "Harbor Dredging Data" to students. Have students spend some time looking at the numbers on the table. Notice the difference between the amounts of sand dredged from the different harbors. Students then choose a harbor that is located on a part of the coast in which they are interested. Perhaps they have visited beaches in that area, camped alongside or visited a major river that is the main sand-carrying river for the area. Students may do more than one harbor, and more than one student may do the same harbor.

Outline

Before class

1. Order video from Coastal Commission (see "Materials" above).
2. Photocopy overhead transparencies and worksheet.

During class

1. Watch video.
2. Whole class discussion on longshore sand movement.
3. Students complete worksheet.
4. Whole class discussion.

4. On the worksheet, students note the average yearly amount of sand (average sand: cubic yards/year) dredged from the harbor and write it down. Next, they calculate how many dump trucks it would take to move this amount of sand over a year (10 cubic yards per truck: trucks/year), visualizing a freeway of dump trucks full of sand moving down the coast. Students then calculate how much it costs to dredge that sand out of the harbors each year ($5 per cubic yard/year).

Results and reflection

After completing the worksheet, lead a whole class discussion on sand movement and littoral cells. You may use the following questions as a discussion guide.

1. When building a harbor, the Army Corps of Engineers usually builds jetties or a breakwater to protect the mouth of the harbor from big waves entering the harbor and destroying boats. When was the last time you heard about big waves wrecking boats in a harbor? Do these jetties and breakwaters do the job they were intended for? What are some other consequences of building jetties? What happens to beaches north of jetties? What happens to beaches south of jetties? Where would you rather have a house on the beach—north or south of a jetty?
2. Many of California's harbors were constructed before this "river of sand" was understood. If you were to build a new harbor today, where would be an ideal location to minimize dredging?
3. Look at the harbor dredging data. Can you tell which harbors are most likely downcoast from a sand sink such as a submarine canyon? Which harbors are likely downcoast from a major river? Check a map to see if you are right.

Conclusions

Truckloads of sand travel down California's sand highway. The sand travels underwater, moved by currents and waves. Beaches are changed and sometimes replenished by the sand highway.

Extensions and applications

The beaches in southern California, especially San Diego and some in Los Angeles, are suffering from lack of sand due to increased coastal and inland development and river damming. What would you recommend to preserve these beaches? (*One alternative is beach nourishment, a costly but sometimes effective remedy that trucks sand to beaches from areas with lots of sand. Once sand is in place, it may stay for several years.*)

References

California Public Beach Replenishment Study, Department of Boating and Waterways and The California Coastal Conservancy, 2002. *www.dbw.ca.gov/beachreport.htm*

Harbor Dredging data courtesy of Gary Griggs, professor of Earth Sciences, University of California, Santa Cruz (UCSC) and Kiki Runyan, UCSC Earth Sciences graduate student.

Harbor Breakwaters and Jetties

Human activities have impacted our coast. One way our coast has changed is through the alteration of the flow of sand when sand is trapped at large structures such as harbor breakwaters and jetties.

Harbor in Santa Cruz shows sand accumulation upcoast.

Santa Barbara Harbor has a long breakwater. The other structure in the photograph is a wharf, with pilings that do not obstruct sand flow.

Headlands and points serve as natural groins along the coast. They trap sand that accumulates on beaches.

Rollin' Down the Sand Highway

1. Choose a harbor from the data table. Notice some harbors need no dredging at all, other harbors need dredging every day, while others need it only every few years or just once or twice, ever. What makes such a difference? *(Hint: Locate your harbor on a map of California and see if it is near a river. Is the river large or small? Where is the harbor in relation to the river? If you have a map that shows submarine canyons, you will have one clue as to why the sand doesn't build up very quickly.)*

2. For your harbor, look at the average of the amount of sand that has been dredged over all the years the harbor has been in operation. What is the total amount of sand that has been dredged? What is the average amount per year (cubic yards of sand/year)?

A Sandy Problem

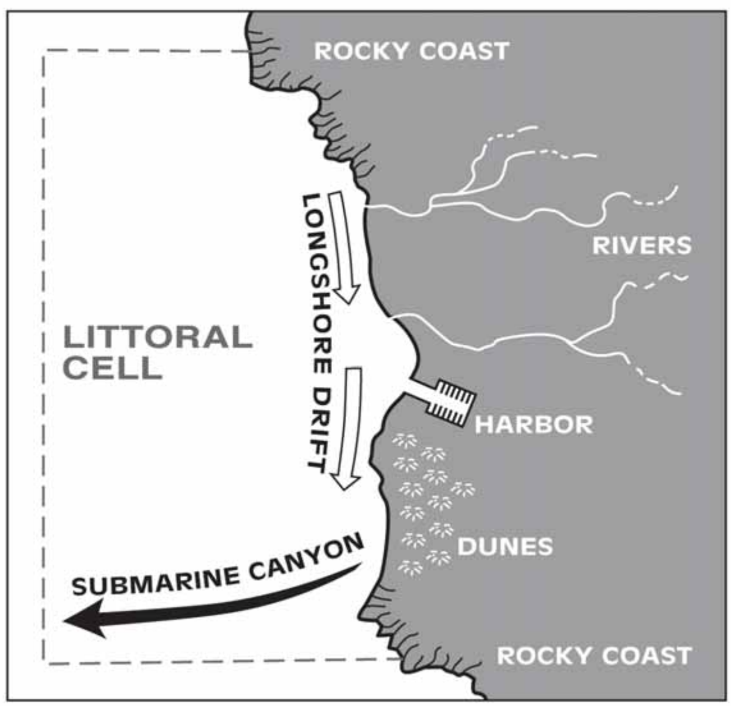
We love beaches, but not in our harbors. How does the sand get there? The predominant direction of longshore sand movement in California is from north to south. An incredible amount of sand is transported underwater by longshore currents. Much of this sand ends up in submarine canyons (in which case the sand is gone from the coast forever because it is too deep to be brought up by small waves).

Large quantities of sand are also carried by winter waves into harbors. This creates a big problem for the harbors that must be kept at a depth so boats can go in and out. Many harbors maintain an adequate depth by periodically dredging sand, a costly necessity. A few natural harbors in California do not need to be dredged: Bodega, Moss Landing, and Newport, for example. Moss Landing and Newport are between or at the upcoast end of littoral cells, and Bodega has a strong enough tidal flow to maintain an entrance channel. Crescent City, Monterey, Redondo-King, and Dana Point are successful constructed harbors that need little dredging because they are at the beginning of a littoral cell, or south of a submarine canyon.

3. Choose a year that is close to the average amount for all the years and use it to make this calculation: One large dump truck can hold 10 cubic yards. How many dump trucks would it take to hold all of the sand dredged from your harbor for one average year (trucks/year)?

4. You are sitting on the beach looking at a calm day on the ocean, but you know there is a lot going on underwater, out of sight. Imagine that all of that sand being carried by the longshore current is actually barreling down the coast in front of you in dump trucks. Over a year's time, how many dump trucks per minute would you see pass by, day and night (trucks/minute)?

5. It costs about $5.00 per cubic yard to dredge sand from harbors to keep them open for boats to sail in and out, and for big ships to conduct their business. How much does it cost each year to keep your harbor open ($/year)?



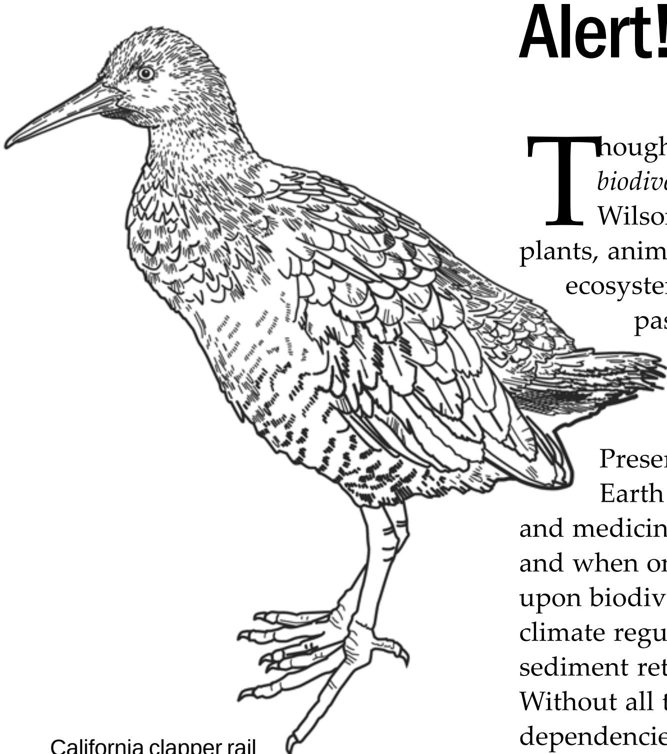
California Harbor Dredging Data

(in cubic yards)

Year	Crescent City	Humboldt Bar/ Entrance	Bodega Bay	San Francisco	Half Moon Bay	Santa Cruz Harbor	Monterey Harbor	Morro Bay	Ventura Harbor	Los Angeles	Newport Harbor	Ocean-side Harbor	San Diego Harbor
1936	48,449												
1937	27,756												
1938	16,353												
1939	58,396												
1940	0												
1941	0												41'-47':
1942	0												29,868,000
1943	0												
1944	0												
1945	0												
1946	0												
1947	0												
1948	0												
1949	0												
1950	0												
1951	0												
1952	0												
1953	0												
1954	0	1,049,574											
1955	0	550,450		1,429,500									
1956	120,466	161,300		309,000									
1957	0	241,000		595,000									
1958	0	243,000		626,000									
1959	0	198,700		3,840,000	Built: no								
1960	0	400,000		763,000	dredging								
1961	0	322,500	302,821	875,000	since								
1962	0	742,500	0	1,145,000									
1963	0	954,500	0	842,000								3,615,175	
1964	187,372	568,788	0	581,000					191,000				
1965	0	362,000	0			70,000			180,000				
1966	0	575,600	0			34,000			143,000			684,000	
1967	0	527,500	0			57,000			239,000			177,910	67'-'76:
1968	0	473,100	106,561			60,000		406,891	257,000			433,890	3,485,000
1969	0	534,000	0			79,000		0	1,883,000			353,000	
1970	0	370,000	0			94,700		0	325,000			0	
1971	0	220,500	0			108,300		0	1,113,000			300,000	
1972	0	405,500	0			90,000		0	17,000			0	
1973	0	319,000	0			109,000		0	1,193,820			346,760	
1974	0	390,500	0			60,000		352,257	420,000			0	
1975	0	381,500	0	1,430,920		91,000		0	160,000			507,712	
1976	61,013	234,800	0	887,254		98,000		0	152,000			459,888	
1977	0	369,000	0	310,000		199,000		0	911,000			0	
1978	0	304,500	0	761,000		55,000		0	496,000			306,470	5,880,000
1979	0	193,098	0	843,500		162,000		0	1,021,500			0	0
1980	0	224,562	69,609	778,635		190,300		596,454	320,000	356,000		0	0
1981	0	465,500	0	0		187,700		0	812,900	0	81,000	461,000	0
1982	125,319	389,030	0	915,816		138,200		0	1,186,000	0	0	0	0
1983	40,221	1,009,876	0	635,500		154,500		0	1,427,000	0	0	406,305	0
1984	0	494,002	0	77,969		79,500		597,000	1,332,900	0	0	473,000	0
1985	0	958,071	0	890,550		145,200		0	0	0	0	0	0
1986	0	991,339	0	903,200		207,000		0	910,000	0	0	393,012	0
1987	0	402,179	0	686,159		206,400		460,000	363,100	0	0	0	260,313
1988	62,192	715,022	0	667,650		230,400		0	800,000	0	0	251,680	130,000
1989	0	429,623	0	198,150		214,500		0	230,314	0	0	0	97,470
1990	0	321,337	0	524,150		173,600		475,321	271,913	0	0	248,970	0
1991	0	410,000	69,082	272,287		163,300		0	377,183	0	0	0	0
1992	0	230,067		441,870		220,600		125,000	524,702	0	0	187,725	0
1993	37,487	651,246		417,672		124,300		0	486,478	0	0	0	0
1994	0	484,721		886,588		234,400		637,000	470,000	0	0	482,642	0
1995	0	635,304		294,070		170,700		1,040,491	271,357	47,022	0	176,107	0
1996	0	474,888		1,008,996		101,900		0	833,000	0	0	162,107	118,563
1997	0	458,693		480,775		118,200		63,009	449,128		0	128,516	
1998	0	632,740		398,758		399,300		115,388	741,975	122,930	268,403	254,000	
1999	35,000	309,274		268,076		317,900		134,234	639,173			172,334	
2000		648,329				262,300		236,883	818,477			282,000	
2001						195,050		180,467	654,000				
Ave.	**12,813**	**464,764**	**17,680**	**722,222**	**0**	**151,412**	**0**	**159,423**	**593,893**	**29,220**	**19,411**	**218,544**	**341,387**

Notes

Chapter 7
Alert! Species in Danger



California clapper rail
Rallus longirostris obsoletus

Though the concept is as old as all creatures on Earth, the term *biodiversity* was first coined by Harvard ecologist Edward O. Wilson in 1988. Biodiversity is the full array of life on Earth: the plants, animals, microorganisms, and the natural communities, ecosystems, and landscapes that support them. Biodiversity encompasses the processes, both ecological and evolutionary, that allow life on Earth to adapt and evolve over time and changing environmental conditions.

Preserving aquatic and terrestrial biodiversity is critical to life on Earth—humans rely on wild biological resources for food, shelter, and medicines. Species depend upon each other in a variety of ways, and when one is eliminated, others may follow. People also depend upon biodiversity for *ecosystem services* such as waste assimilation, climate regulation, water supply and regulation, erosion control and sediment retention, soil formation, waste treatment, and pollination. Without all the species of the world, with their intricate interactions and dependencies that have taken sometimes millions of years to evolve, the world would be a different place. Though it is impossible to bring back extinct species, we can learn about how biodiversity works, how to protect rare and endangered species, and how to care for natural communities and ecosystems so they can support biodiversity.

New Words

biodiversity; ecosystem services; biome; rare, threatened, and endangered species; endemic species; adaptation

California Coastal Commission Areas of Critical Concern: Rare and Endangered Species, Wetlands

Relevant California Science Content Standards, Grade 7: Life Sciences (3.a,b,d,e)

Every species on Earth lives in a *biome*. Biomes are large, distinct areas of land or water that have a similar climate, soil, plants, and animals. Different biomes contain different habitats for plants and animals. The U.S. contains the widest spread of biome types, ranging from rain forest to Arctic tundra, of any country in the world. It also has the largest number of known species of any temperate country—200,000 or so, and new species are being discovered each year. However, over the years as our country has focused on economic and material gains, we have taken for granted, overlooked, and in many cases destroyed natural resources and native plant and animal species. California's wetlands, one of our most beautiful and productive biomes, have been hit particularly hard; we have lost 90 percent of our original wetlands, and many of the remaining wetlands are in danger of being harmed by nearby development. Another biome under attack is the intertidal zone; aggressive, invasive, nonnative species threaten to overcome some intertidal plants and animals.

Over geologic time, some species become extinct as others evolve, resulting in an array of biological diversity. While extinction is a natural process over the long run—the life of any one species can run from 0.5 to 10 million years—in recent history, extinction rates have increased rapidly. As of January 2003, a total of 539 U.S. species are recorded in the Natural Heritage Central Databases as extinct or missing. This list

Grade 7 Activities

These activities encompass species diversity; biodiversity; rare, threatened and endangered species; ecosystem services; biome; and evolutionary adaptations.

Activity Goals

7.1. Here Today, Gone Tomorrow

Students will:

1. Define native and non-native species.
2. Identify and describe causes of extinction within animal and plant species.
3. Define "threatened," "rare," and "endangered."
4. Identify local threatened or endangered species.
5. Identify the factors affecting potential elimination of wildlife species.

7.2. Adapted for Survival?

Students will:

1. Describe adaptations of birds to their environment.
2. Explain how the adaptive characteristics of a bird enable it to survive in its environment.
3. Describe why extinction of a species could occur when the environment changes and the adaptive characteristics of the species are insufficient for its survival.

7. 3. Survivor: California

Students will:

1. Understand the processes and limiting factors that drive evolution.
2. Find solutions to present day problems facing species survival.

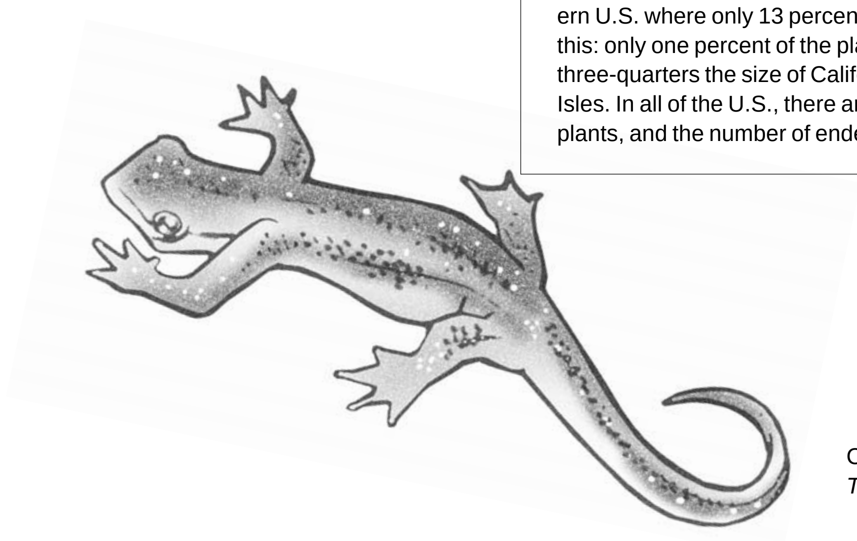
includes only species, but if subspecies and varieties were included, the list would be much larger. California ranks third in the nation in numbers of extinctions (35), behind Hawaii (249) and Alabama (96). Many of California's native plant and animal species are in peril of extinction today because their environment can no longer support them: there are 373 species or subspecies listed as either threatened or endangered by the State of California or the federal government. One of the reasons so many are listed is that 1,500, or 26 percent of the native species found in California, are endemic—they are found no place else on Earth.

In prehistoric time, extinctions were caused by natural disasters and competition with other species. Today the main causes of species extinctions include habitat destruction, pollution, and other side effects of our increasing population. In addition, in our global economy, people, planes, and ships can travel quickly and often between countries, oceans, and ecosystems. Native species are being forced out by foreign invasive species that are able to out-compete native species for habitat. Often, introduced species do not serve the same functions in the habitat, such as food and shelter for other species. This spells disaster for the plants and animals that depend upon a displaced native species for survival.

Scientists make discoveries every day that help us understand the natural processes that govern life on Earth. In fact, much of the environmental degradation we see today is a result of yesterday's mistakes, misunderstandings, lack of knowledge, and shortsighted actions. But things can change—learning more about how natural systems work helps us understand how we can take care of our planet Earth.

Background material adapted from:
Precious Heritage: the Status of Biodiversity in the United States. Stein, B.A., Kutner, L.S., and Adams, J.S., 2000. The Nature Conservancy and the Association for Biodiversity Information. Oxford University Press.

One of California flora's outstanding features is that more than one-third (36 percent) of its native species, subspecies, and varieties are endemic. If looking at species alone, it is still an astounding 26 percent. Compare this with the entire northeastern U.S. where only 13 percent of the flora is endemic. Consider this: only one percent of the plants of the British Isles, an area three-quarters the size of California, are endemic to the British Isles. In all of the U.S., there are 19,473 identified species of plants, and the number of endemic species is 4,036.



California newt
Taricha torosa

Grade 7 Activity

Brown pelican
Pelecanus occidentalis

Science skills

- Researching
- Investigating
- Deducting
- Communicating

Concepts

- *Rare*, *threatened*, and *endangered* are words used to describe plant and animal species in varying degrees of danger of becoming extinct.
- Our actions can decide whether a species is tipped over the edge to extinction, or brought back to increase in numbers for future generations.

California Science Content Standards

3. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept, students know:
3.a. Both genetic variation and environmental factors are causes of evolution and diversity of organisms.
3.e. Extinction of a species occurs when the environment changes and adaptive characteristics of a species are insufficient for its survival.

Activity 7.1
What's So Special About Native Species?

If extinction means gone forever, what about the threatened, rare, or endangered species? Discover the distinctions, and then learn about some special plants and animals in your own neighborhood.

Background *(may be photocopied for student reading)*

California has a diverse and extraordinary wildlife. More than 1,275 species of mammals, birds, reptiles, amphibians and fish live within our borders, and many are found nowhere else in the world. About 6,300 flowering plants, gymnosperms, ferns, and fern allies are native to California, more than we find in the entire northeastern United States and adjacent Canada, an area ten times larger than California. California has the largest number of native plant species in the nation, and another thousand plants that are non-native, weedy introductions, or escapees from gardens and agricultural fields.

The term "native species" is used to describe a plant or animal that is a native of California, that is, for as long as it can be traced back, its origins have not been found to be from out of the state. Native species have been here for so long they are specifically adapted to our climate, soils, and habitats. The California sagebrush is a native species, as is the California sea lion. Many of California's native plants are also "endemic species"—this term means a species is found naturally nowhere else on Earth.

Non-native species, also known as introduced or exotic species, are species whose arrival in California have been documented—they came from somewhere else, such as European dune grass (*Ammophila arenaria)* which was intentionally introduced to stabilize dunes along the coast. Unfortunately, we now know it is an aggressive invader that has naturalized along the dunes and coastal wetlands, overtaking areas previously covered by native species with greater wildlife value. A number of programs are involved in erradicating European dune grass and replacing it with non-invasive native species that include grasses and perennials historically found in the area.

Because native species are special, they have special status. Native species that are in peril of extinction are considered rare, threatened, or endangered (see definitions below). California's flora and fauna, especially its rare plants, are increasingly threatened by the spread of urbanization, conversion of land to agriculture, alteration of natural hydrological cycles, recreational activities, invasion of habitat by non-native plants and animals, and pollution. Many of the unique habitats that harbor rare plants are being destroyed. About forty California native plants probably became extinct in the last century, and hundreds more are endangered and could perish if present trends continue.

It is difficult to pinpoint an exact number of species that become extinct each year around the world, as many plants and animals are still

California English-Language Arts Content Standards

Writing

2.3. Write research reports:

a. Pose relevant and tightly drawn questions about the topic.

b. Convey clear and accurate perspectives on the subject.

c. Include evidence compiled through the formal research process (e.g., use of a card catalog, *Reader's Guide to Periodical Literature*, a computer catalog, magazines, newspapers, dictionaries).

d. Document reference sources by means of footnotes and a bibliography.

Objectives

Students will:

- Define native and non-native species
- Identify and describe causes of extinction within animal and plant species
- Define *threatened*, *rare*, and *endangered* species
- Identify local threatened or endangered species
- Identify the factors affecting potential elimination of wildlife species

Time to complete

Background data gathering: allow three to four weeks for sending away to receive information by mail (allow less time if using e-mail). Whole class discussion: 30 to 45 minutes. Student or small group work on individual species: report to be worked on over a one-week period.

Mode of instruction

Teacher led discussion. Background data gathering by Internet (preferred) or letter writing. Whole class discussion. Student or small group report.

unnamed and unknown. Human beings have become a hundred times more numerous than any other land animal of comparable size in the history of life. Our species appropriates 40 percent of the solar energy captured in organic material by plants. There is no way that we can draw upon the resources of the planet to such a degree without drastically affecting the condition of most other species. There is some controversy regarding the estimates of extinction rates for plants and animals. Some scientists estimate that human activity is responsible for the extinction of 100 plants and animals each day; that's almost four species extinctions per hour. Other scientists offer lower figures, but few experts disagree with the belief that the rate of species extinction is being accelerated by human actions.

Extinction is a problem across the United States. As of December 2002, the U.S. Fish and Wildlife Service (USFWS) list of the total number of species that are endangered or threatened is 1,258 (515 animals, 743 plants). California's rare and threatened species make up a large part of this list, and many other species from our state are under review for classification as threatened or endangered.

The U.S. Endangered Species Act of 1973 gives authority to protect endangered species to the U.S. Departments of Interior and Commerce, with responsibilities further delegated to the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. It is not easy to get a new species added to the federal list of endangered or threatened species. In order to list, reclassify, or delist a species, the USFWS must follow a strict legal process for proposing a new rule. The rule is first proposed in the *Federal Register*, a U.S. government publication. After a public comment period, the USFWS decides if the rule should be approved, revised, or withdrawn.

There can be differences in state and federal lists of endangered, threatened, or rare species. These differences occur because habitats, and the species that live in them, cross state lines. An animal or plant may have been lost within one state's boundaries, but may be abundant in another and therefore not considered threatened by USFWS. Individual states have their own lists of rare, threatened, or endangered species. In California, the California Department of Fish and Game enforces the California Endangered Species Act (CESA) which identifies procedures so individuals, organizations, or the Department can submit petitions to the Fish and Game Commission requesting that a species, subspecies, or variety of plant or animal can be added to, deleted from, or changed in status on the state lists. Once a species is on this list, it has special protection and any project that threatens one of these species (such as development, hunting season, or catch limits) must undergo a more intensive review to ensure that the listed species is protected.

Although extinction is a natural process, excessive and intensive human activities in the environment cause a dramatic increase in its rate. Loss of habitat as a result of human activity is considered to be the most common cause of species extermination. Other major causes of species extermination and endangerment include unregulated or illegal com-

Materials

1. Internet access (preferred) or query letter writing to obtain information from state and federal agencies about listed plants and animals
2. Poster board and poster supplies
3. Writing materials
4. "Species in Peril" worksheet and "California Endangered Species Resource List"
5. Overhead projector

Outline

Before class

1. Review definitions.
2. Photocopy "Species in Peril" worksheet and resource list for each student.
3. Reserve a day in the computer lab.
4. Photocopy onto overhead transparency or copy onto blackboard the "Species Listing Status" table.
5. Plan the extensions your class will complete and gather materials as required.

During class

1. Review and discuss term definitions.
2. Hand out "Species in Peril" worksheet and species resource list.
3. Describe report preparation requirements and deadlines.

mercial and personal use, disruption of migration routes and breeding behaviors, pollution, human disturbance, predator control, competition or predation from introduced species, and natural causes.

Generally accepted definitions of the terms used in this activity are:
Endangered Species: in immediate danger of extinction.
Critically Endangered Species: will not survive without direct human intervention.
Threatened Species: present in its range, but threatened because of a decline in numbers.
Rare Species: not currently in danger, but of concern because of low numbers. (Some species were always rare because of their position in the food chain or due to habitat preference.)
Extinct species: complete disappearance of a species.

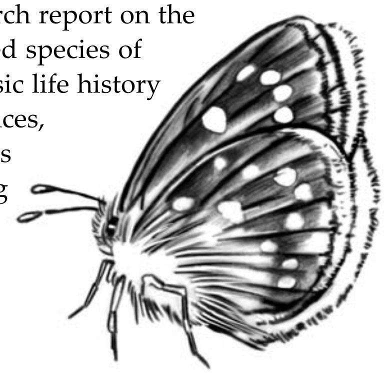
Activity

1. Ask students what they know about native species, and rare and endangered species. What do they think about protecting endangered species in California? Why do it? Write their responses on the board. Review and discuss with the students the definitions of threatened, endangered, rare, and extinct, as used in wildlife conservation as well as in a dictionary. Note that words defined in a standard dictionary may have additional legal connotations outside the dictionary.

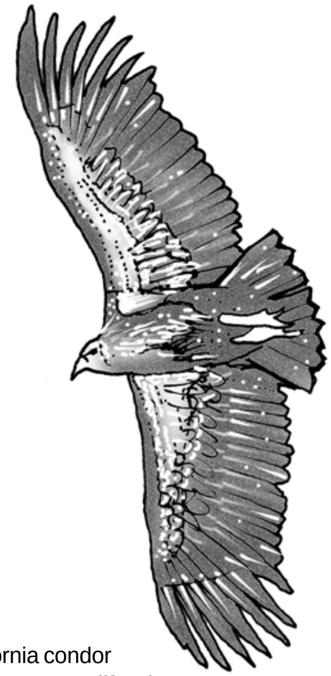
2. Hand out "Species in Peril" worksheets. Using the Internet, by e-mail, or U.S. mail, have students contact the California Department of Fish and Game and research the lists of plants and animals that are classified as endangered, critically endangered, threatened, rare, or extinct in California. Students may contact local chapters of conservation organizations (see list on worksheet) for additional information on species of concern. Post the list.

3. Each student or pair of students will select from the list a rare, threatened, or endangered mammal, reptile, bird, plant, fish, invertebrate, or amphibian (preferably a coastal species) to research and write a report. See worksheet for research questions.
Caution: Be sure that each student or team is working on a species that is not already being researched by someone else in the class.

4. Students or pairs will produce a research report on the California rare, threatened, or endangered species of their choice. Information will include basic life history description, habitat and feeding preferences, migration patterns (if applicable), reasons for listing, current status, and steps being taken to preserve the species.



Xerces blue butterfly
Glaucopsyche xerces



California condor
Gymnogyps californianus

Hearst's ceanothus
Ceanothus hearstiorum

Results and reflection

1. Upon completion of research reports, each student or group will briefly present his or her findings to the entire class.
2. Make a table on the blackboard or overhead projector that looks similar to this:

Species Listing Status Table

Plant or Animal	California Status	Federal Status	Factors Affecting Status

As students present their data, fill in the blanks on the table. Upon completion, list the most prevalent factors affecting the species (habitat loss, pollution, impact from introduced species, etc.). Why would some species be on the California list but not on the federal list? Discuss what can be done to reduce impacts on listed species.

Conclusions

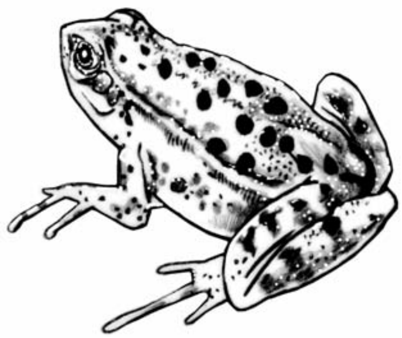
Species extinction is a factor of evolution, but the rate at which species are becoming extinct is rapidly increasing due to human actions. Federal or state listing of plants and animals as rare, endangered, or threatened is a first step towards protection of these species.

Extensions and applications

1. Students or pairs may create a poster on their species, and have a class-wide Rare and Endangered Species Poster Session where they present their results and what they have learned about their species.
2. Look at web sites with data on rare/endangered wetland species and exotic species introductions. Are there species in peril in your area? Students may research a local problem, its history and present state, suggestions for future, and recommendations for action. Are any actions being taken now to protect these species in your area? Find out what organization is responsible for protecting these species and ask a representative to visit your classroom. After your research, as a class write a letter to support their actions and send it to the editor of your local newspaper (see Appendix D for tips on how to write an effective letter).
3. Have groups of students choose a state government agency or a conservation group to research how they are protecting endangered plants and animals in California. What can each of us do to help protect native plants and animals?
4. Do some research on native species in your area. Take a field trip and try to find your native species in nature. Have students bring blank paper and a clipboard to record their observations, or record their experience in a nature journal. What was the habitat like—was it sufficient to support a large population of the species? Was the species thriving? Have students draw a map of the field trip area, and mark where the species occur. Is the species near water, the shade of trees, a hillside, or in an open meadow? Are there other species that the chosen species is dependent upon for survival? Map them, too. What are the limitations posed by the habitat that would keep species from thriving?

Draw them on the map. How would students modify the area to provide room for their species to increase? How would it affect other plants and animals living in the area?

5. Research an invasive species, explain how it is impacting native California species, and describe possible solutions to the problem.



California red-legged frog
Rana aurora draytonii

Adapted from

Here Today, Gone Tomorrow. © 1992, 1985, 1983 Council for Environmental Education. Reprinted with permission from Project WILD, *Project WILD K-12 Education Activity Guide*. The complete activity guide may be obtained by attending a Project WILD workshop. For more information, contact the National Project WILD Office at (713) 520-1936 or the California Department of Fish and Game, (916) 657-2672.

Additional references and background material gathered from:
California Native Plant Society. 1722 J Street, Suite 17, Sacramento, CA 95814. (916) 447-2677 *www.cnps.org*
California Environmental Resources Evaluation System (CERES) (*www.ceres.ca.gov*), a program of the California Resources Agency (*www.resources.ca.gov*)
California Department of Fish and Game. 1416 Ninth Street Sacramento, CA 95814. Phone: (916) 445-0411 *www.dfg.ca.gov*

Caution! Invasion of the Exotic Algae

Caulerpa taxifolia, an alga native to tropical waters, is popular in home saltwater aquaria. This fast grower has invaded intertidal and subtidal areas throughout the world. *Caulerpa* blankets an area, pushing out invertebrates, fish, and native plants. It is thought to have entered coastal waters worldwide by people dumping their aquaria into household drains, storm drains or directly into the sea. *Caulerpa* outcompetes native plants, is toxic to many fish, and adversely affects invertebrates.

In 2000, *Caulerpa* was discovered in a half-acre area in a lagoon north of San Diego. It was eradicated by covering the infested site with plastic tarps and injecting chlorine, thereby killing everything underneath. This technique has been successful in eradicating this infestation and one other within California.

To prevent future invasions, *Caulerpa* has been banned from sale in the U.S. If you have *Caulerpa* in your aquarium, dispose of it immediately by freezing it for 24 hours and placing it in the trash; never flush it down a drain or dump it in the street or local water body. Aquarium water should not be dumped outside, but may be disposed of down a toilet or sink. Additional information is available in the Southern California Caulerpa Action Team website, www.sccat.net.

Xerces blue butterfly
Glaucopsyche xerces

Species in Peril Worksheet

California newt
Taricha torosa

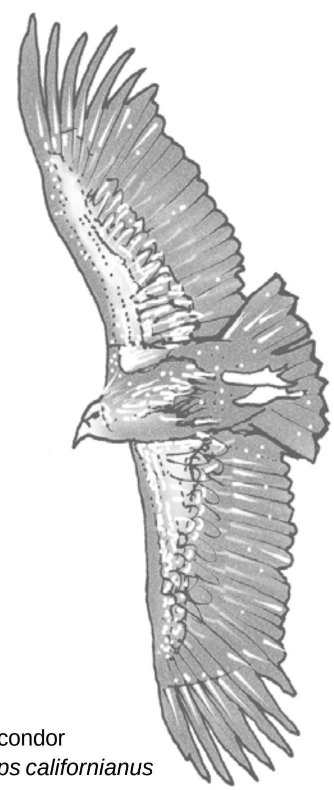
Term	Definition	Example
Species	Groups of populations whose members are capable of interbreeding in nature to produce fertile offspring and do not interbreed with members of other species	**Humans**
Native species	A species' origins cannot be traced from out of the state	**California newt**
Endemic species	Occurs naturally in one area; not found in nature elsewhere	**Island grey fox**
Rare species	Not presently in danger, but of concern because of low numbers (Some species were always rare because of their position in the food chain or due to habitat preference)	**Hearst's ceanothus**
Threatened species	Present in its range, but threatened because of decline in numbers	**Southern sea otter**
Endangered species	In immediate danger of extinction	**Beach layia**
Critically endangered	Will not survive without direct human intervention	**California condor**
Extinct species	Complete disappearance of a species	**Santa Barbara song sparrow**

Research Report

Write a two page report. Include the following information in your report:

1. Basic life history description, including illustration or photograph of species
2. Habitat and feeding preferences
3. Past and current range
4. Migration patterns (if applicable)
5. Reason for listing
6. Current status
7. Steps being taken to preserve the species

Southern sea otter
Enhydra lutris nereis



California condor
Gymnogyps californianus

California's Endangered Plants and Wildlife (2004)

The following are listed by the State of California or the federal government as rare, threatened, or endangered.

Mammals: 31 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/temammal/temammala.shtml

Plants: 218 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/teplant/teplanta.shtml

Reptiles: 13 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/tereptil/tereptla.shtml

Amphibians: 12 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/teamphib/teamphiba.shtml

Birds: 33 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/tebird/tebirda.shtml

Fishes: 34 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/tefish/tefisha.shtml

Invertebrates: 32 species and subspecies
www.dfg.ca.gov/hcpb/species/t_e_spp/teinvert/teinverta.shtml

California Endangered Species Resource List

California Department of Fish and Game
Habitat Conservation Planning Branch
1416 Ninth St., Sacramento, CA 95814
(916) 653-4875 *www.dfg.ca.gov/hcpb/index.shtml*

U.S. Fish and Wildlife Service
Pacific Region

Conservation Projects
California Coordinated Resource Management and Planning
California Environmental Resources Evaluation System (CERES)
California Legacy Project (CCRISP)
California Oak Mortality Task Force
Integrated Hardwood Range Management Program
Natural Resource Projects Inventory

Conservation Organizations
California Biodiversity Council
California Native Plant Society
Ecological Society of America
National Audubon Society, California chapter
The Natural Areas Association
The Nature Conservancy
California Partners in Flight
Riparian Habitat Joint Venture
Society for Conservation Biology
The Wildlife Society

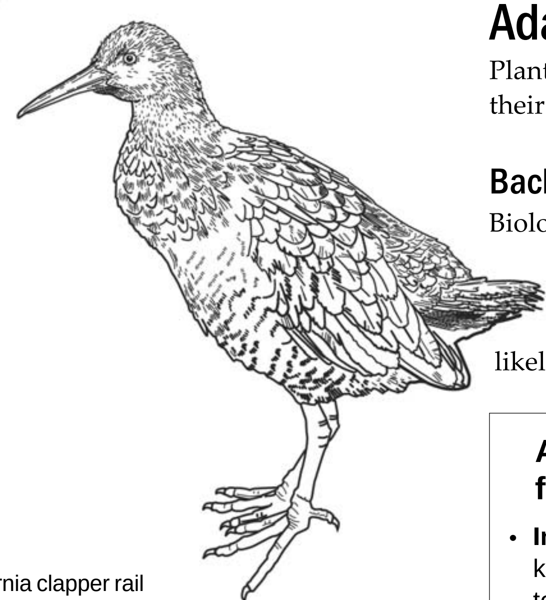

Hearst's ceanothus
Ceanothus hearstiorum

Research and Universities
California Academy of Sciences
Information Center for the Environment, University of California, Davis
Los Angeles Museum of Natural History
San Diego Natural History Museum
Santa Barbara County Museum of Natural History
University of California Cooperative Extension
Forestry Natural Resources News Calendar

Grade 7 Activity

Activity 7.2
Adapted for Survival?

Plants and animals have adaptations that allow them to survive within their habitat. Design a habitat and a bird to thrive in it.



California clapper rail
Rallus longirostris obsoletus

Background

Biological evolution accounts for the diversity of species that has developed through gradual processes over many generations. Mutations occur randomly, but the ones that better allow an individual to survive and reproduce within its habitat are more likely to spread throughout the population.

Animals are more vulnerable to extinction from human impacts if they:

- **Interfere in some way with people's activities.** Some animals may kill livestock, eat or ruin crops, or feed on animals that people also like to eat. Because they interfere with peoples' activities, these animals may be shot, poisoned, or harmed in some other way (*e.g., eagles, wolves, jaguars, tigers, and geese, ducks, and birds that eat crops*).
- **Migrate**. Animals that migrate depend on several different habitats and are very vulnerable to habitat destruction. For example, songbirds, butterflies, turtles, and whales migrate great distances; if the habitat they are migrating to no longer provides the food or shelter they seek, they may not make it back.
- **Have very specific food or nesting requirements.** Some animals are picky about what they eat or where they live. They are adapted to eating only one type of food or live in only one habitat, and become endangered if their food sources or nesting site disappears. Native species who have adapted along with a specific environment also have to compete with introduced species. One example is bluebirds, a species native to North America, that have a hard time competing for nesting sites with starlings introduced from Europe in the early 1900s.
- **Are sensitive to changes in their environment.** For example, birds of prey are very sensitive to chemical changes in their environment, such as the introduction of pesticides.
- **Have small broods and long gestation periods.** If animals give birth to only one or two young every year or every two or three years (such as elephants, bats condors, and others), when their populations decline it takes much more time to recover because of the low birth rate. Sometimes they become extinct before they have time to make a comeback. For example, sharks have a very low reproduction rate—some species bear only one young per year—but cockroaches have 80 young every six months!
- **Are naturally rare.** Some animals and plants are naturally rare throughout their range, and others have a limited range. These animals are more vulnerable to habitat destruction. For example, many of the native plants and animals that live on the islands of Hawaii are naturally rare, and as more people move into the area, many of these already rare species face habitat loss, competition from introduced species, new diseases, and other problems.

From: Endangered Species: Wild and Rare, National Wildlife Federation, Learning Triangle Press, 1997. Reproduced with permission of The McGraw-Hill Companies.

Science skills

- Observing
- Describing
- Hypothesizing
- Analyzing
- Comparing

Concept

Plants and animals have specific adaptations that contribute to the survival of the individual, and ultimately the species.

California Science Content Standards

Life Sciences

3. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept, students know:

3.a. Both genetic variation and environmental factors are causes of evolution and diversity of organisms.

3.e. That extinction of a species occurs when the environment changes and adaptive characteristics of a species are insufficient for its survival.

Objectives

- Students will describe adaptations of birds to their environment.
- Students will explain how the adaptive characteristics of a bird enable it to survive in its environment.
- Describe why extinction of a species could occur when the environment changes, and the adaptive characteristics of the species are insufficient for its survival.

Time to complete

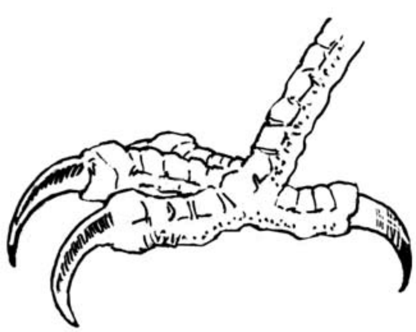
One hour and fifteen minutes

Mode of instruction

Pairs of students choose a habitat, draw it, and design a bird to live in it. Pairs share what they have designed and their rationale in small groups, then share with larger class. The activity includes a worksheet on the California clapper rail.

Materials

1. One large poster-size piece of paper and one small piece of paper (8 ½" x 11") for each student pair
2. Markers, colored pencils, scissors, and tape
3. Copies of "Adapted for Survival?" and "Create a Bird" worksheets, one per student pair
4. One copy of "Habitat Descriptions," photocopied and cut into cards
5. Copies of "California Clapper Rail" worksheet, one per student

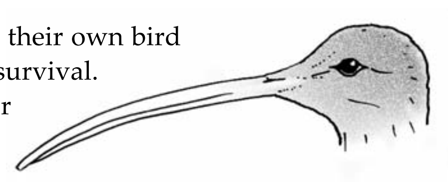


When a habitat changes, either slowly or catastrophically, the species with characteristics better adapted to the new conditions are the ones most likely to survive. Some species have adapted to such a narrow range of habitat conditions that they are extremely vulnerable to change and may be more susceptible to death or extinction than other species.

Activity

1. Begin the activity with a discussion of what students know about habitats and adaptations. What are some common habitats in California? What are some adaptations plants and animals have that help them survive in these habitats?

2. Introduce the story of the California clapper rail as an example of how a species can be extremely dependent on a specific habitat. Either read aloud, or students read to themselves "California Clapper Rail." After reading, hold a classroom discussion about the story. On which habitats are the clapper rail dependent? What is happening to these habitats? If time, you may have students answer the questions at the bottom of the worksheet or send home as homework.



3. Explain that students will create their own bird that is dependent on a habitat for survival. Divide students into groups of four and hand out one set of materials to each group (one poster-size piece of paper, one 8 ½" x 11" unlined piece of paper, "Adapted for Survival" worksheet, and drawing pens or pencils).

4. Two members of each group will choose a habitat card out of the "hat" (salt marsh, redwood forest, freshwater pond, grasslands, mountain, desert riparian or river habitat, and beach). <u>Make sure that each group of four students has two different habitats to work with.</u>

5. Have students in each group choose a partner. Each pair of students will work with one habitat. The pairs draw the habitat on the poster paper following the written descriptions on the cards.

6. After drawing the habitat, each pair must choose from the "Create a Bird" worksheet adaptations for beak shape, foot type, and nesting strategy. Students design and draw their bird to fit their habitat based on their chosen adaptations. They will draw, color, and cut out their bird separately from the habitat so they can exchange habitats later.

7. When student pairs are finished, they complete the "Adapted for Survival" worksheet, and then share their bird with the class, explaining its adaptations and why the bird is well suited to its particular habitat.

8. After sharing, pairs trade habitats with the other pair in their group. Each pair must then discuss among themselves and answer worksheet questions pertaining to the fate of their bird in its new habitat. Could it survive, and why? Each pair will discuss their birds' ability to survive in the new habitat with the other pair in their group.

Preparation

Gather poster materials. Photocopy "Habitat Descriptions" (two copies only, then cut into squares), "Create a Bird," and "Adapted for Survival," and "California Clapper Rail" (one each per student).

Outline

Before class

Photocopy materials and gather poster materials.

During class

1. As a class, read "California Clapper Rail" story and discuss.
2. Divide students into groups of four.
3. Students pair up within groups.
4. Pass out poster and smaller paper, one to each pair.
5. Student pairs choose a habitat description from the hat, then draw it on the poster paper.
6. Student pairs choose from the "Create a Bird" worksheet to design and draw a freestanding bird to live in their habitat.
7. Each pair explains their results with the other pair in the group.
8. Pairs exchange habitats with each other, place their bird in its new habitat, and discuss its fate.

Results and reflection

Assessment is embedded in the activity. If the students have previously read excerpts from Darwin's *Theory of Natural Selection*, there may be time for a whole class discussion on the bonus question: What role do adaptations play in Darwin's theory?

Conclusions

Many characteristics of plants and animals have adapted over time to ensure survival in their habitat. If their habitats change quickly, these plants and animals may not survive.

Extensions and applications

1. Species that do not survive habitat change or other obstacles are more prone to become rare, endangered, or extinct. Students may choose one of the habitats and identify plants and animals that are rare or endangered in the habitat. What is the reason for their endangered status? What has happened in particular to their habitat that has made it difficult for them to survive? Are there species in neighboring habitats that may be affected by the loss of this species or this habitat? Students may write a short research report based on these questions.
2. Some fish populations are declining because of overfishing. What characteristics make certain species more vulnerable to overfishing? (*Long lives, late reproduction, etc.*). See Appendix C for some interesting facts about overfishing.

Adapted from

Adapted for Survival. Save The Bay's San Francisco Bay Watershed Curriculum (Based on *Fashion-A-Fish*, found in Aquatic Project Wild and published by the Western Regional Environmental Education Council.)

Adapted for Survival?

Introduction

Does the coloration of an animal affect its chances for survival? Do feeding mechanisms influence an organism's chance of living? How would an organism's reproductive strategy affect the individual? How would it affect the species? Throughout time, people have marveled at the great amount of diversity found in nature. It is these adaptations that have led to Earth's vast array of spectacular life forms and enormous variety among species. Adaptations are any feature that increases an organism's reproductive success (or fitness) in its environment. In this activity, you will study the effects that adaptations have on a bird's success in different California habitats.

Create a Bird Instructions

1. **Read** the description of the habitat your pair has chosen and draw the habitat on the large piece of paper, showing details such as plants, animals, water, soil, etc.

2. **Design** a bird to live in this habitat.
   a. Choose one of each type of adaptation for beak, feet, and nest, using the "Create a Bird" page.
   b. On another sheet of paper, list and describe your bird's specific adaptations.
      1) What does it eat and how does it get its food?
      2) How does it build its nest, reproduce, and raise its young?
      3) How does it protect itself from predators?
      4) Explain why your bird is adapted to survive in its specific habitat.

3. Using the smaller piece of paper and pencils provided, **design, color, and cut out** one bird showing all of the adaptations you have chosen and described. Use your imagination to add details!

4. **Assign** your bird a scientific name (genus first letter capitalized, species in all lower case) and a common name. Write both on the other sheet of paper, and on the back of your bird.
For example: Scientific name: Genus, species (e.g., *Studentus restlifolius)*
Common name (e.g., restless student):

5. **Place** your bird in its habitat.

6. When all groups have finished designing their birds, your pair will **explain** to the group how your bird is adapted for this particular environment. Describe the habitat your bird lives in and the adaptations that are most important to your bird's survival in this habitat.

7. **Trade** habitats with another group, keeping the bird you designed.

8. **Place** your bird in the new habitat and reevaluate the probability of success for your bird. After placing your bird in its new habitat, answer the questions below.

ANALYSIS QUESTIONS

Answer these questions on the other sheet of paper:

1. List and justify any adaptations that will limit the success of your bird in its new habitat.

2. List and justify any adaptations that will enhance the success of your bird in its new habitat.

3. Which adaptation is most important for the survival of the individual bird? Explain your reasoning.

4. Which adaptation is most important for the survival of your bird's species? Explain your reasoning.

5. BONUS: What role do adaptations play in Darwin's *Theory of Natural Selection*?

Adapted for Survival?

Habitat Descriptions

1. Salt Marsh
Salt marshes are wetlands found at the edges of bays and estuaries. The tide carries salty water in and out of the marsh. Low-growing plants, such as pickleweed and cordgrass, grow here. Plankton and fish live in the water, crabs and clams burrow in the mud, and mice and insects live in the plants.

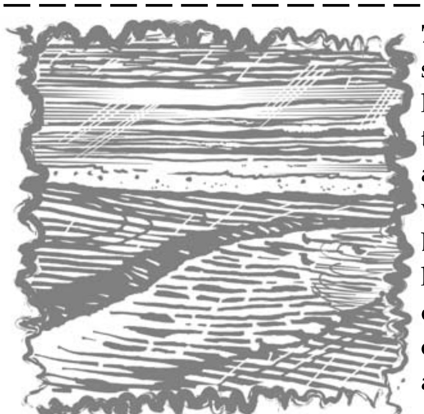
2. Redwood Forest
Redwood forests exist where fog creates a moist environment. Tall redwoods form a dense canopy that shades the forest floor. Ferns, moss, and fungus grow in the understory and redwood needles form a soft blanket of duff on the ground. Squirrels, slugs, and deer live in the forest.

3. Grasslands In California's Central Valley, low-lying flat areas are covered with grasses. Lizards and snakes bake on exposed rocks. Kit foxes and kangaroo rats roam during the night. Summers are hot and winters are cold.

4. Mountains/Alpine
In the high elevations of the Sierra Nevada mountain range, granite peaks are inhabited by pine trees and aspens. Snow falls through the winter and melts in the spring, running down creeks to rivers. The air is crisp and cold.

5. Desert. Much of southern California consists of arid regions that are typically hot during the day and cool at night. Very little rain falls, and all of the plants and animals have to find ways to conserve water and tolerate the heat.

6. Riparian. Located alongside rivers and streams in California, riparian habitat includes willow, alder, buckeye, cottonwood, and oak trees. A wide variety of animals seek shelter, food, and water in these shady areas. The river water flows over rocks and sandy areas inhabited by invertebrates and fish.



7. Beach/Shoreline. Sandy shore is where ocean meets land. Invertebrates live in the sand. Dead bits of kelp and animals are washed up with the tides each day. Decomposers work at drift kelp lying on sand. Sand dunes form at highest points on beach, and beach grasses and flowering plants grow.

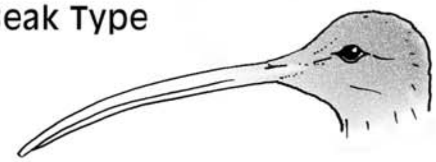
Teacher Instructions

1. Make 2-3 copies of this sheet, depending upon class size (you will need one habitat for each pair of students; if you have 28 students, make 2 copies, which yields 14 habitats).
2. Cut along dotted lines, and place in a "hat" for student pairs to select a habitat.
3. Discuss in class each habitat to add to the descriptions so students can make accurate drawings.
4. Student pairs design a bird to live in their habitat.

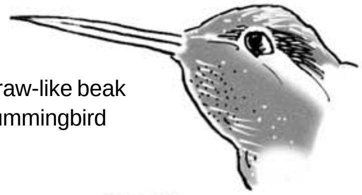
Create a Bird

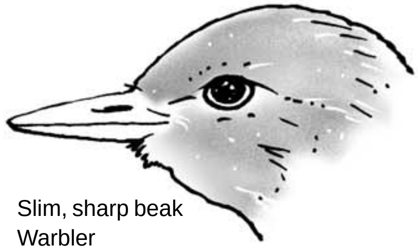
1. Choose a habitat.
2. Choose a beak.
3. Choose a foot type.
4. Choose a nesting strategy.
5. Draw your bird.
6. Place it in its habitat.

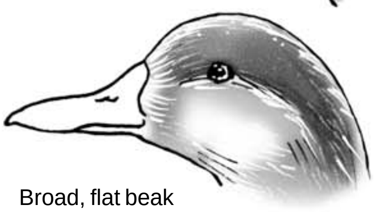
Beak Type


Long, slender beak
Long-billed curlew

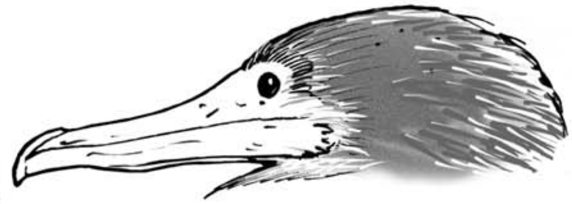

Sharp, hooked beak
Hawk


Straw-like beak
Hummingbird

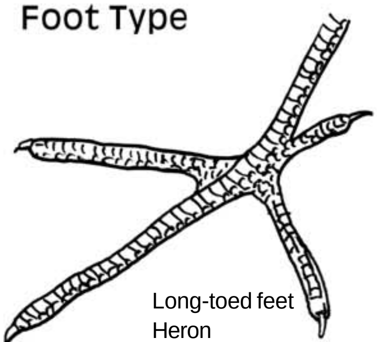

Slim, sharp beak
Warbler

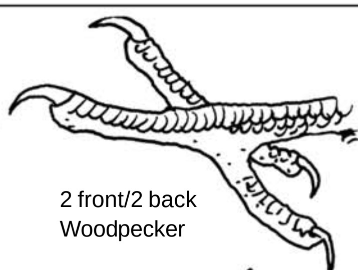

Broad, flat beak
Mallard

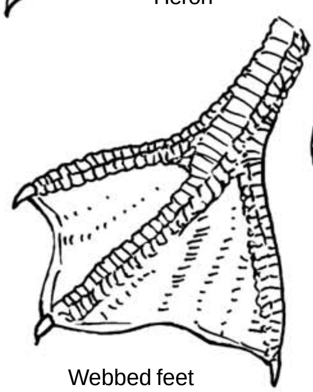

Long, broad beak
Heron

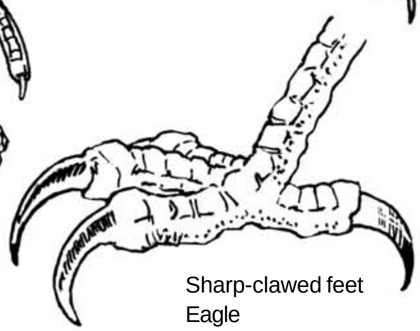

Long, hooked beak
Cormorant

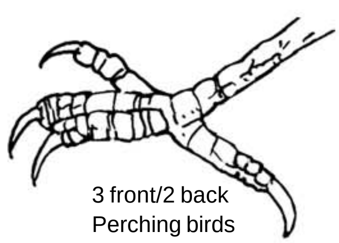
Foot Type


Long-toed feet
Heron


2 front/2 back
Woodpecker


Webbed feet
Duck

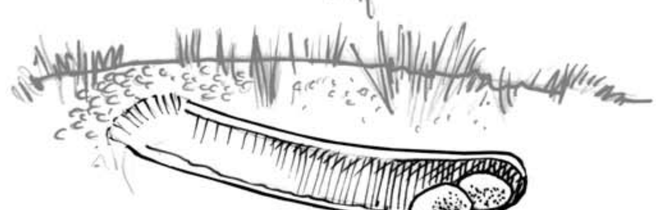

Sharp-clawed feet
Eagle


3 front/2 back
Perching birds

Nest Type

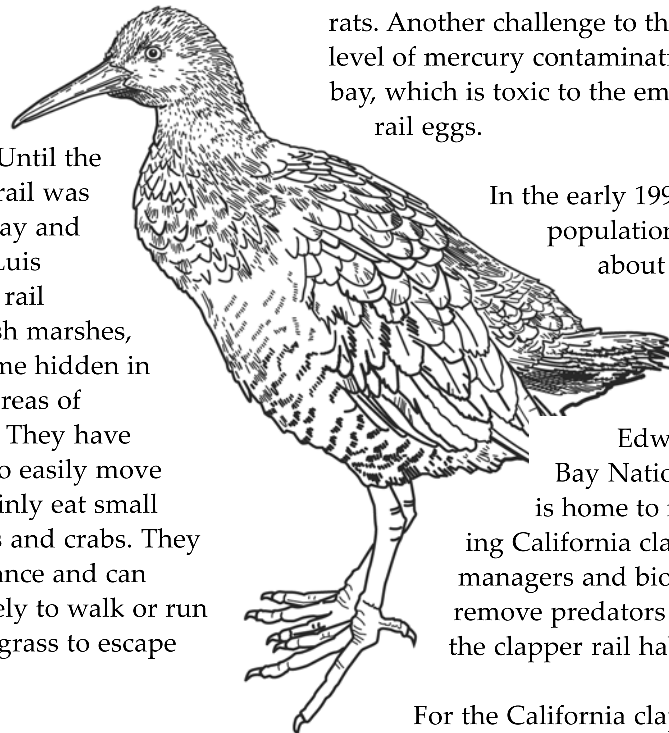

Ground nest


Tree or bush nest


Burrow nest

California Clapper Rail: Story of an Endangered Species

The California clapper rail, *Rallus longirostris obsoletus*, is a native California species listed as endangered under both federal and state law. Until the late 1800s, this species of clapper rail was found as far north as Humboldt Bay and as far south as Morro Bay in San Luis Obispo County. The habitat of the rail consists of coastal salt and brackish marshes, where they spend most of their time hidden in dense vegetation, particularly in areas of pickleweed and Pacific cordgrass. They have flattened bodies that allow them to easily move among the tall grass. The rails mainly eat small invertebrates such as snails, clams and crabs. They seldom fly more than a short distance and can swim fairly well, but are more likely to walk or run to the nearest dense stand of cordgrass to escape danger.



California clapper rails were once abundant in marshes along the coast. From 1850 to the early 1900s, over-hunting greatly reduced the population. During this time, rails were served in San Francisco restaurants and shipped off to feed gold miners. Clapper rail hunting was made illegal in 1918 with the Migratory Bird Treaty Act, but the birds were then faced with loss of their wetland habitat. About 85 percent of the original marshland in the San Francisco Bay has been lost. Most of the marsh was filled so that cities could be built on the once-wet mud. Some of the marsh was converted to ponds to produce salt. Laws enacted since the 1960s have limited the destruction of wetlands, requiring extensive permits and studies in order for any filling to occur.

Though their previous habitat covered much of the coast, California clapper rails are now only found in the remaining marshes of San Francisco Bay. In their reduced habitat, they face new, introduced predators such as red foxes, feral cats and Norway rats. Another challenge to the birds is the high level of mercury contamination in parts of the bay, which is toxic to the embryos inside clapper rail eggs.

In the early 1990s, the clapper rail population reached a low of about 500. The population now may be as large as 1,500 due to conservation efforts. The Don Edwards San Francisco Bay National Wildlife Reserve is home to many of the remaining California clapper rails. Refuge managers and biologists work to remove predators and keep them out of the clapper rail habitat.

For the California clapper rail population to continue improving, more marshland habitat must be made available. There are many wetland restoration efforts currently in progress. In 2002, Cargill, Inc. agreed to sell 16,500 acres of former salt ponds to the State of California and the federal government for wetland restoration, which will increase the San Francisco Bay's existing tidal wetlands by 50 percent. This project will take many years to complete, but its existence provides a brighter outlook for the future of the California clapper rail.

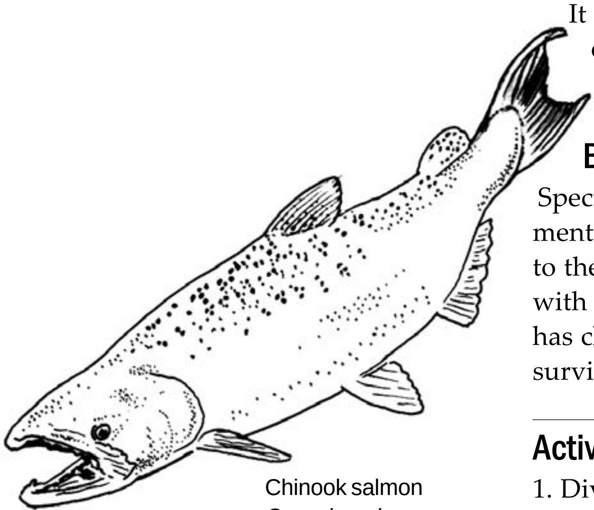
Questions:

1. How is the California clapper rail adapted to the salt marsh?
2. What issues have affected the California clapper rail in the past and what issues are affecting it now?
3. Is it important to protect the remaining salt marshes? Why?

Grade 7 Activity

Activity 7.3 Survivor: California

It can be hard for a species to adapt in light of present day environmental challenges. See if you are one of the lucky few to beat the odds and survive in this game of life.



Chinook salmon
Oncorhynchus spp.

Background

Species spend hundreds of thousands of years adapting to the environmental conditions of Earth, and thousands of years adapting specifically to the local conditions in California. Over the past 150 years, beginning with the Gold Rush, there has been a human population explosion that has changed the natural environment forever. How will these species survive the changes? Is survival or extinction next for them?

Activity

1. Divide the students into six groups. Student groups sit in a semi-circle facing the "Survivor: California" game board. Explain that all groups will start out at the beginning of the phylogenic tree, and can choose their own paths as they evolve. All paths have the same number of steps; the cards they draw will determine how quickly they move on the board. Two groups cannot evolve into the same species, so there are limits to the routes each group can take on the phylogenic tree.

2. The scenario cards describe historical events that have changed Earth's environments. Natural selection determines the differential survival of groups of organisms. Organisms that were adapted to a particular change survived, while others died or failed to reproduce. **Make sure the students realize that these scenario cards are not in correct historical order, as they are drawing them from the bag randomly. The scenario cards demonstrate many of the factors that have occurred over the history of life on Earth that have affected the evolution of species BUT the scenario cards may not have truly affected the particular species the students are evolving into in this game. Emphasize that this is a simulation!**

3. Now is your chance to evolve! Each group rolls the dice. The highest roll gets first pick from the scenario bag, play proceeds around the room counterclockwise. Each group takes a turn drawing scenario cards from the bag. After drawing a card, each group needs to choose together which forks to take on the phylogenic tree and decide where to move on the board. As they make their choice and evolve, mark their spaces on the overhead with six differently colored dry-erase markers. Used cards go back in the bag.

4. The game ends once each group reaches the end of the game board and becomes a present-day species. At this point, place the "Species Cards" in a "hat" and have groups appoint a representative to draw a card. Groups will draw according to the species "number" they arrived at on the game board. Tell students to pretend that the evolutionary path they followed in the game led them to become the species on their card.

Science skills

- Analyzing
- Hypothesizing
- Deducting
- Predicting

Concept

Exploding population growth in California creates new limits to survival and species evolution.

California Science Content Standards

Life Sciences

3. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept, students know:

3.a. Both genetic variation and environmental factors are causes of evolution and diversity of organisms.

3.b. The reasoning used by Darwin in making his conclusion that natural selection is the mechanism of evolution.

3.d. How to construct a simple branching diagram to classify living groups of organisms by shared derived characteristics, and expand the diagram to include fossil organisms.

3.e. Extinction of a species occurs when the environment changes and adaptive characteristics of a species are insufficient for its survival.

Objectives

Students will:

- Understand the processes and factors that drive evolution.
- Find solutions to present day problems facing species survival.

Time to complete

One class period

Mode of instruction

Students play a board game followed by a whole class discussion.

Materials

1. Overhead projector
2. Overhead transparency copy of "Survivor: California" game board
3. Dry erase markers (6 different colors)
4. "Scenario Cards" photocopied onto card stock
5. "Species Cards" photocopied onto card stock and cut out

Preparation

Conduct Activity 7.1 previous to this activity, so students understand definitions and importance of rare and endangered species and the factors that may create challenges to survival.

Outline

Before class

1. Photocopy onto a transparency "Survivor: California" game board.
2. Photocopy Scenario Cards and Species Cards onto card stock, and cut up.
3. Place Scenario Cards into bag labeled "Round 1."

During class

1. Divide students into six groups.
2. Explain game instructions.
3. Play game.
4. Each group presents their solutions to the rest of the class as the class votes, Survival or Extinction.
5. Whole class discussion wrap-up.

5. All groups have evolved to become a present-day species that depends upon California's unique environment to survive. Is survival or extinction next for these species? It's in the cards. In order for a group's species to survive, they must come up with some reasonable solutions to their threats to survival. Allow groups time to discuss solutions to the problems on their "Species Cards." Each group will then present their solutions to the rest of the class, and the class will vote: Survival or Extinction.

Results and reflection

1. After the solutions are discussed, hold a class discussion about evolution and threats to survival. Questions for possible discussion include: Is evolution happening today? Are the rapid extinctions of large numbers of species that occur now "natural?" Why would we want to save species from extinction?

Conclusions

Environmental changes induced by an expanding human population add new factors that affect the ability of highly evolved species to survive.

Extensions and applications

1. Research a locally rare or endangered species in your area. Define the predominant factor affecting its ability to survive or become extinct. Find three ways that protection of this species can be assured. Would there be any negative impacts on human communities if the species is protected?
2. Research a species that has become extinct in California. What caused its decline? If we knew then what we know now about extinction and biodiversity, would it have made a difference—would the people have made different choices? Write a short story on how things could have turned out differently.
3. Visit a natural area that is known to harbor a rare or endangered species. If you can locate your species in the wild, leave it where it is and draw a scientific illustration that includes the habitat in which you found it. Are there any plants or animals that have a special relationship with your species? If so, draw them in the picture also. Record the date, location, and weather on your drawing.

Adapted from

Survival or Extinction. Save the Bay's San Francisco Bay Watershed Curriculum. Survival or Extinction activity adapted from the *Limiting Factors/Evolution Game* by Amy Quillen and Gail Correy, as part of the Woodrow Wilson Leadership Program in Biology.

Additional References
California Department of Fish and Game: *www.dfg.ca.gov/hcpb/*
California Native Plant Society: *www.cnps.org*
California Environmental Resources Evaluation System (CERES) (*www.ceres.ca.gov*), a program of the California Resources Agency (*www.resources.ca.gov*)
Save The Bay: *www.savesfbay.org*

Survivor: California

Scenario Cards

Congratulations! You have evolved to the point where you have lungs! Evolve 2 spaces.

Your species is contributing to biodiversity of the land mammal population. Evolve 2 spaces.

A volcanic eruption has distributed ash on all land vegetation. Regress 2 spaces.

An abundance of food in the ocean has increased the biotic potential of your species. Evolve 1 space.

An increase in atmospheric CO2 causes an increase in phytoplankton in the ocean, increasing the fish population (your food supply). Evolve 1 space.

Volcanoes are erupting all over Earth's surface, but you are relatively unaffected due to the buffering effect of your ocean. Evolve 2 spaces.

A meteor has created a nuclear winter. The added insulation provided by your fur has increased your chance for survival. Evolve 2 spaces.

Your food supply is successful and provides you with a stable food supply for a long period of time. Evolve 3 spaces.

As a result of tectonic movement, desert habitat has become a redwood forest. Other species fail to adapt and you thrive. Evolve 2 spaces.

Your ability to filter feed on krill using your baleen allows you to eat lower on the food chain (a helpful adaptation). Evolve 3 spaces.

Increased CO2 in the atmosphere has melted the polar ice caps, decreasing the ocean's salinity and upsetting the osmotic balance of plankton, your food supply. Regress 2 spaces.

An increase in the population of krill has brought different species into your area of the ocean. Your ability to compete allows you to evolve to the next level. Evolve 1 space.

An increase in carbon dioxide has contributed to an increase in land vegetation. Evolve 1 space.

Your forelimbs have broadened, making you a much better swimmer. Evolve 2 spaces.

You have the ability to give birth to live young. Since you need not worry about egg snatchers, evolve 1 space.

A small population becomes geographically separated from the rest of the species, due to a newly formed mountain range. Evolve 2 spaces.

Your water environment filters out much of the solar radiation before it gets to you. Evolve 3 spaces.

The Ice Age ends and bays are formed as water levels rise. This provides you with habitat. Evolve 2 spaces.

A decrease in temperature causes freezing of the polar ice caps. Land mass increases. Evolve 3 spaces.

Sedimentation from rivers flows into your bay, increasing your wetland habitat. Evolve 2 spaces.

The salinity in your ocean increased due to a long period of increased climate temperature. These stresses reduce your ability to reproduce. Regress 1 space.

The loss of your legs over many generations has made you more streamlined. This increases your swimming speed and your success as a species. Evolve 2 spaces.

You win in the Darwin gene pool. Evolve 3 spaces.

You win in the Darwin gene pool. Evolve 3 spaces.

Survivor: California Species Cards

HUMAN

Limits to Survival: Emissions from cars and industry are causing greenhouse gasses to build up. Global warming will threaten your ability to grow food, and melt the polar caps which will raise sea level. Low lying coastal areas will be underwater.

Humans
Homo sapiens sapiens

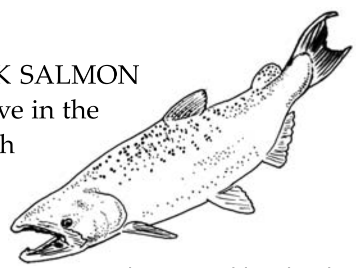
BROWN PELICAN

Limits to Survival: DDT, a now banned pesticide once used in agriculture and still found in soil, makes its way to the oceans. DDT weakens your eggshells, causing them to crack. You are unable to successfully reproduce.

Brown pelican
Pelecanus occidentalis

WINTER RUN CHINOOK SALMON

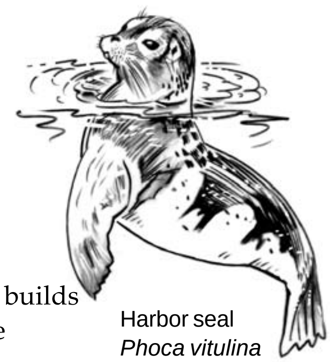
Limits to Survival: You live in the ocean, but lay eggs in fresh water rivers and streams. Dams have been built on nearly every California river, and you are unable to return to your breeding grounds in order to reproduce.



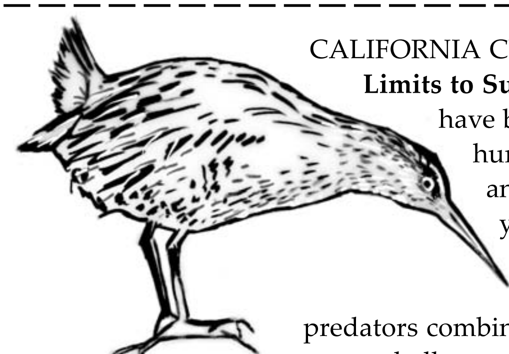
Winter run Chinook salmon
Oncorhynchus spp.

HARBOR SEAL

Limits to Survival: Pollution from streets, yards, agricultural fields, farms, and industries flows into California's ocean and bays each day. Polluted plankton are eaten by fish and you eat the fish. Ultimately, pollution builds up in you, and you are unable to reproduce.



Harbor seal
Phoca vitulina



CALIFORNIA CLAPPER RAIL

Limits to Survival: Red foxes have been introduced by humans to California and are eating you and your young. About 1500 California clapper rails remain: predators combined with habitat loss create challenges to survival.

California clapper rail
Rallus longirostris obsoletus

SALT MARSH HARVEST MOUSE

Limits to Survival: Your salt marsh habitat is disappearing. Only 10% of all California's salt marshes are left and they are threatened by development.

Salt-marsh harvest mouse
Reithrodontomys raviventris

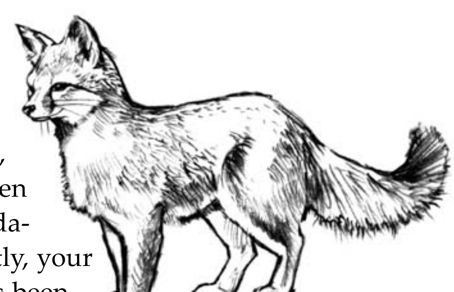
CALIFORNIA RED-LEGGED FROG

Limits to Survival: Your populations were decimated by humans for food by the begining of the 1900s. Predators such as non-native bullfrogs, crayfish, and fishes have taken care of what's left. You have disappeared over 99% of your former range, and your riparian habitat is constantly threatened.

California red-legged frog
Rana aurora draytonii

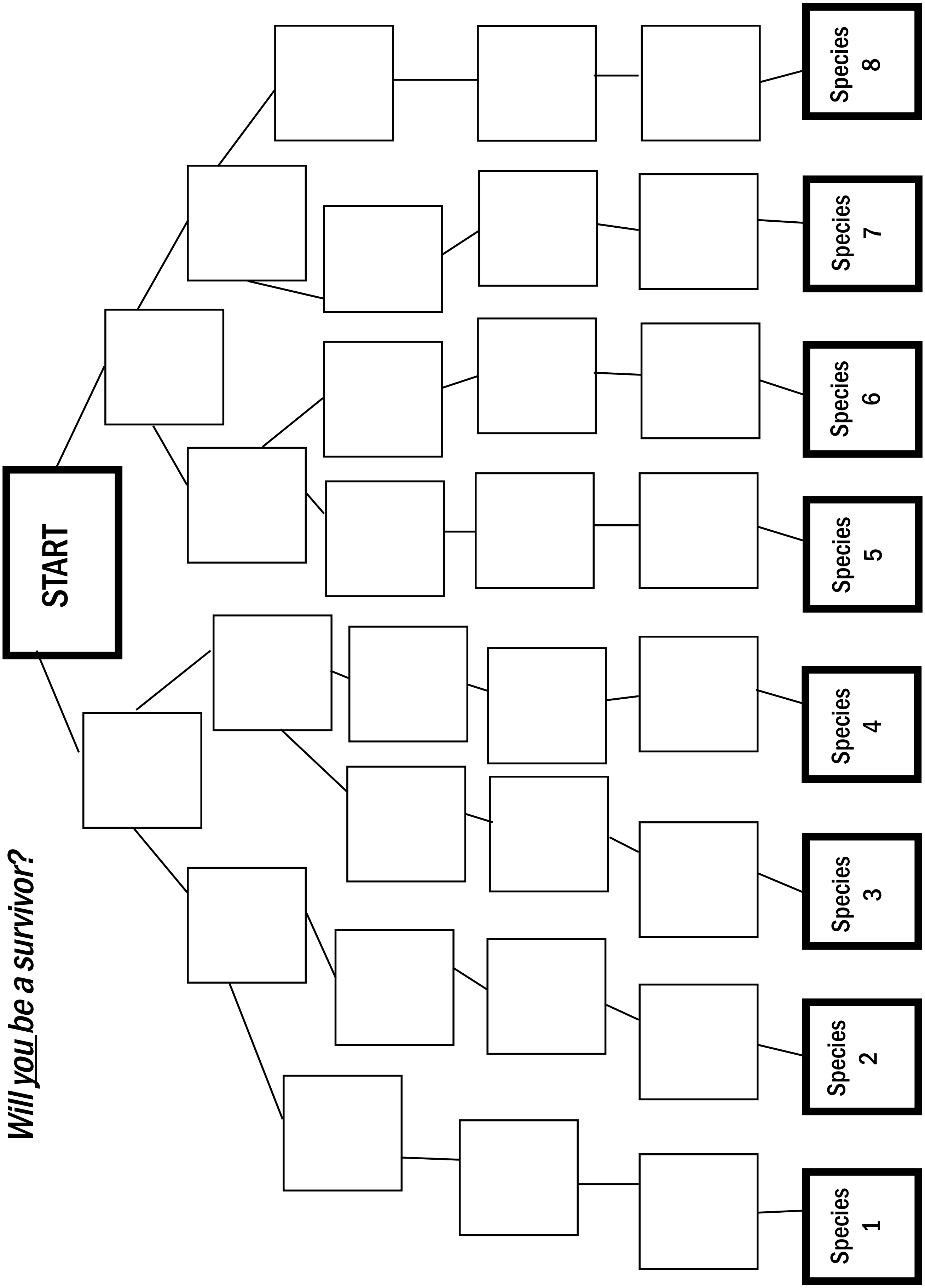
ISLAND FOX

Limits to Survival: Your life on the Channel Islands is threatened by disease, predation by the golden eagle, loss and degradation of habitat. Recently, your dramatic decrease has been due to golden eagles who have begun to nest on the islands. However, golden eagles are also endangered.



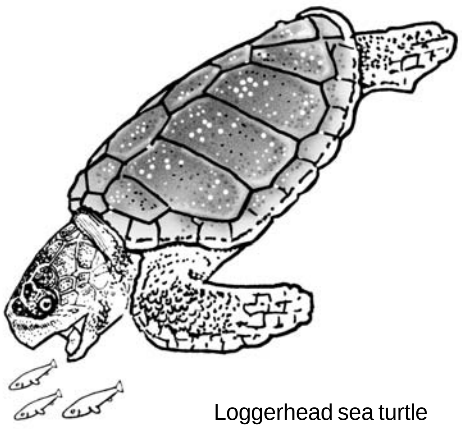
Island fox
Urocyon littoralis

SURVIVOR: CALIFORNIA
Will you be a survivor?



Notes

Chapter 8: That Sinking Feeling



Loggerhead sea turtle
Caretta caretta caretta

The properties of water enable life on Earth to survive—water supports biological functions, and its physical properties shape our planet's surface and atmosphere. On land, moving water is the most important agent of erosion, as it works to shape and create our beaches. Salinity influences the density of water, and in the ocean the properties of temperature, density, and salinity interact to create currents that affect global climate. This chapter looks at two of water's physical processes, buoyancy and density, and some of the ways in which our lives are affected by these processes.

Buoyancy is the upward pressure exerted upon an object by the fluid in which it is immersed; this pressure is equivalent to the weight of the fluid that the object displaces. In general, heavy objects sink and light objects float, but much depends upon the shape, size, and density of the objects. Water's buoyant properties allow particles to be transported further than on dry land because the particles can be lifted with less energy, and are subject to less friction in the water.

Density is the mass or amount of matter per unit of bulk or volume. The density of water is so great that many heavy materials are more buoyant in water than on dry land: common rocks have an apparent weight loss of 20 to 40 percent when in water. Whether it's moving a boulder downstream during a flood, floating a plastic six-pack ring down a river and out to sea, or floating a huge oil tanker, water's physical properties affect the world around us every day.

New Words
buoyancy; density; salt water wedge; Plimsoll Mark

One of the ways that water's buoyant properties works against us is in the transport of marine debris, in particular, plastic. Plastic, because of its strength, durability, and buoyancy, makes up the greater part of all debris found in the ocean and is by far the most harmful. More than 90 percent of floating marine debris is plastic—about 650,000 plastic bottles end up in the ocean each day. In the eleven year period between 1990 and 2001, the highest quantity of floating plastic measured in the central North Pacific rose from 316,000 pieces per square kilometer (1990) to nearly 1 million pieces per square kilometer (2001).

California Coastal Commission Areas of Critical Concern: Coastal Processes, Marine Debris

Relevant California Science Content Standards, Grade 8: Buoyancy and Density, 8.a-d.

Marine mammals, birds, turtles, fish, and invertebrates can be harmed by plastic loops, fishing line, nets, strings, and bands, which entangle them, wound them, and/or prevent them from swimming and feeding. Marine animals are also susceptible to ingesting all forms of plastic debris, in particular cigarette filters, small plastic pieces, and pellets (or "nurdles") that form the raw material for plastic products and are frequently found floating at sea.

Grade 8 Activities

These activities demonstrate the power of two of water's physical processes, buoyancy and density, and the ways in which they: 1) determine which objects sink and float, 2) influence the distribution of marine debris and subsequent harm to marine life, and 3) drive the dynamics of salt and fresh water mixing in productive estuaries.

Activity Goals

1. Keep Your Head Above Water

Students will:

1. Predict outcome, and conduct a hands-on lab to compare which things float and which sink.
2. Explore the concept of density and specific gravity.

2. You Are What You Eat: Plastics and Marine Life

Students will:

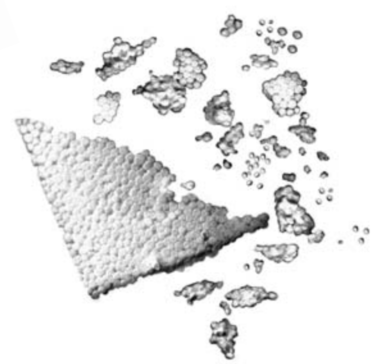
1. Understand that different types of plastics float, sink, or stay neutrally buoyant.
2. Identify where ten marine species feed in the water column.
3. Make the connection between where a marine organism feeds and the types of pollutants to which it is exposed.

3. The Edge of the Wedge

Students will:

1. Demonstrate why fresh water will stay at the surface while salt water travels up a river along the bottom in a wedge.
2. Describe the water characteristics of an estuary from salty ocean water, to brackish water and fresh water.

Plastic does not biodegrade, and often floats, making it especially attractive to wildlife. Marine animals such as some sea turtles and many seabirds are prone to eating plastic. Sea turtles ingest plastic bags or balloons after mistaking them for jellyfish, a favorite food. Ingestion of plastic can cause intestinal blockages, and can also cause a false sense of satiation, which can lead to starvation.



Grade 8 Activity

Southern sea otter
Enhydra lutris nereis

Science skills

- Observing
- Measuring
- Predicting

Concepts

- Water has physical properties of density and buoyancy

California Science Content Standards

Density and Buoyancy

8. All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept, students know:
8.a. Density is mass per unit volume.
8.b. How to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume.
8.c. The buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced.
8.d. How to predict whether an object will float or sink.

Objectives

Students compare the way things float or sink in fresh and salt water.

Time to complete

One class period

Mode of instruction

Teacher directed group work, followed by hands on experiments.

Activity 8.1
Keep Your Head Above Water

Do things that float behave differently in salt and fresh water? What lets them float, and when do they sink?

Background

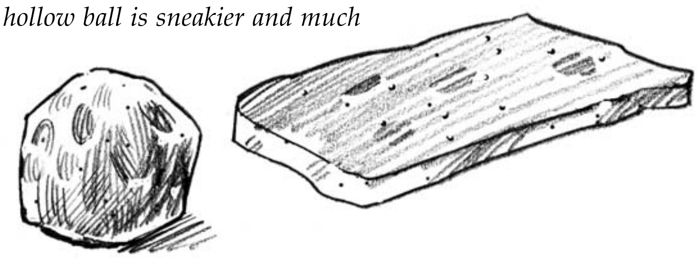
Buoyancy can be a difficult concept to understand. The idea that some things sink and others float is straightforward, but the reasons behind these observations are not so easy to accept. Density is also a challenging concept: the weight per unit volume of objects. This activity uses an experimental approach in which students don't formally identify the concepts, but observe them in action.

Activity

1. Begin a discussion of students' own perceptions of floating and sinking. Have they ever been swimming in salt water? Fresh water? Which was easier to float in? Have they ever been to the Great Salt Lake or seen people floating in it in a picture? How about the Dead Sea (also a salt lake)? *In your class you may be able to find at least one student who has made the observation that it is easier to float in salt water than in fresh water.* Explore students' ideas of what makes things float in water, and why it might be different in salt water.

2. Tell students they will have an opportunity to conduct experiments with buoyancy and density. Hand out "Float or Sink?" worksheet. Begin with a challenge: Can the students design an object that floats in salt water and sinks in fresh water? Let them experiment with film canisters and pennies (13 to 14 pennies in a plastic film canister usually works) in salt and fresh water in measuring cups. To catch spills, place the cups in aluminum pans first. Does a film canister holding the same number of pennies behave differently in two different solutions? How many pennies in a film canister will float in fresh water? How many will salt water support?

3. Does a ball (about 1 inch diameter) of clay sink or float? It sinks. If the student changes its shape, will it still sink? Try it flat or elongated in a bucket of water. It still sinks. Can the students figure out how to make it float? (*Forming it into a boat is the easy answer. Making it into a hollow ball is sneakier and much harder. Clay might be shaped around a ping-pong ball to make a hollow clay ball. It takes a great deal of trapped air to make the clay float*.) Has the weight of the clay changed? Measure it. (*No*.) What has changed? *Its volume. Its weight per unit volume has changed with the addition of air space.*



Materials

For each student or small group

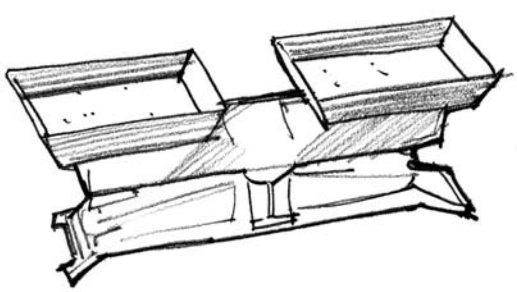
1. "Float or Sink?" worksheet
2. Four 35 mm plastic film canisters
3. 50 pennies
4. Two clear plastic two-cup measuring cups or large drink cups
5. One inch chunk of modeling clay (sold in sticks like butter) per student or group
6. Two pans to catch drips
7. One ping pong ball
8. 250 gm Ohaus spring scale (optional)
9. Rubber bands to hook to the scale
10. Optional: "Shipping in Dangerous Waters—Buoyancy Matters!" handout

For entire class

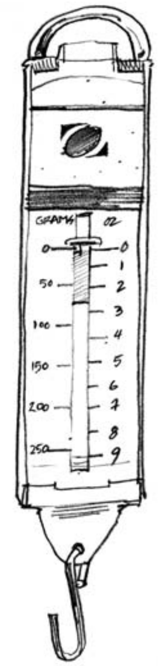
1. Fresh water in gallon plastic milk containers at room temperature (1.5 cups per student or group)
2. Very salty water (6 cups table salt or kosher salt per gallon) in plastic milk containers at room temperature (about 1 1/2 cups per student or group)
3. Bucket of fresh water

For extension activities

1. Graduated cylinders
2. Accurate top-loading balance



4. You may have conducted previous experiments with fresh and salt water where students learned that a volume of salt water weighs more than an equal volume of freshwater; the salt water is more dense than the fresh water. If you have a spring scale, attach the canister holding 13 pennies to the scale with a rubber band and lower it into each kind of water. What happens to the apparent weight in each kind of water? Can the students observe the water supporting the weight of the object? It should be "weightless" on the scale when it floats. If it sinks, it will still weigh less than when measured in air. *The water is supporting the canister. The fact that objects weigh less in water is why water has been used to transport heavy things throughout human history, from logs to oil tankers. Salt water can support heavier objects because it is more dense than fresh water.*

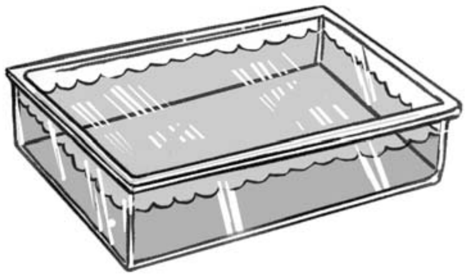


Results and reflection

1. Have students predict what would happen to a very heavily loaded boat as it sails from the ocean up into a river, and write their predictions on their worksheet. *It would sink lower and lower as the water became fresher.* Where harbors and shallow areas have fresh water input, boats have to be partially unloaded out to sea (a process called lightering) to keep them from getting stuck on the bottom as they sail up from the ocean. Have the students noticed marks painted on big ships that tell how low the ships are sitting in the water? *Salt water can float a heavier object of the same size than fresh water.* **Optional:** pass out to students a copy of "Shipping in Dangerous Waters—Buoyancy Matters!". Students may read this article and hold a classroom discussion on the practical aspects of understanding buoyancy.

2. How do species live that have adapted to live in both fresh water and seawater? *Anadromous species, such as salmon, live the bulk of their lives in the ocean, but are born and give birth in fresh water.* Or species that live in tidal wetlands, where part of the time they are in fresh water, and part of the time in salt water, all within a 12-hour daily cycle? *Species such as pickleweed can excrete excess salt from its tissues.* Have a whole class discussion on this topic.

3. What happens when fresh water hits salt water, as when a river empties into the sea? How might this affect the plants and animals in salt water and fresh water? How might it affect the transport of pollutants carried in the fresh water?



Preparation

Gather materials, photocopy worksheet. Mix salt water the day before, using hot water to dissolve the salt. Let solution sit to room temperature.

Outline

Before class

Mix salt water solution.

During class

1. Have students discuss what they know about floating and sinking.
2. Students use film canisters and pennies to experiment with floating and sinking.
3. Students design something that sinks in freshwater and floats in salt water.
4. Students complete worksheet.
5. Whole class discussion.

Conclusions

Objects weigh less in water than on dry land because of water's buoyant properties. Salt water is more dense than fresh water, and because of this, buoyant properties of salt water are different than fresh water.

Extensions and applications

1. You may introduce the concept of *density* by having the students calculate the weight per unit volume of objects. Density equals mass divided by volume:
   a. Weigh each object on a balance to find the mass.
   b. Find the volume of the objects by filling a larger graduated cylinder part way with water and a bit of detergent to break the surface tension. Record the level. Then sink the object below the surface and record the new volume. Subtract the volume of the water from the volume of the water plus object to find the volume of the object.
   c. Mass divided by volume equals density.
   d. When all the objects' densities have been calculated, arrange them in order on a list.

2. What is the density of the fresh water? The salt water? To find out, weigh a measured volume (again, mass divided by volume equals density, so weigh it first, then divide by the volume, or mls.). Where do fresh water and salt water fit in the list of densities? Can students make a statement about density of an object versus density of a fluid with regard to whether it sinks or floats? *(If the object is less dense than the fluid, it will float. If it is more dense, it will sink.)*

3. Students may calculate the *specific gravity* of each object. Weight depends on gravity. Things weigh less on the moon where the gravity is less than on Earth, but they have the same *mass*. Relative mass can be expressed as specific gravity. Specific gravity generally uses distilled water at 4ºC as a standard and sets it equal to 1. Everything is compared to it. You could use cold tap water without being too far off. Divide the density of an object by the density of the fresh water to get the object's specific gravity. For example, if the object were 2 g/cubic centimeter (milliliter) and water is 1 g/cubic centimeter (milliliter), then the specific gravity of the object will always be 2 although the object's weight will change with gravity.

4. Interested students can investigate the Dead Sea. Why is it called the Dead Sea? Is it really dead? If not, what lives in it? How did it become the way it is now?

Adapted from

Keep Your Head Above Water. In: *Living In Water*, the National Aquarium in Baltimore. 1997. Visit the National Aquarium in Baltimore web site: *www.aqua.org*

Float or Sink?

Object	Salt water: Float or Sink?	Fresh water: Float or Sink?
1. Canister with 13 pennies		
2. Canister with ___ pennies		
3. One inch ball of clay		
4. Clay ball flattened out		
5. Clay ball different shape		
6. Other objects (i.e., clay boat with pennies):		

1. Draw a clay shape that floats successfully in both freshwater and saltwater.

2. **Predict**: Knowing what you know about how things float differently in salt water and fresh water, answer this question: What would happen to a very heavily loaded boat as it sails from the ocean up into a river? Draw a picture of a boat travelling from the ocean as it sails up a river.

Shipping in Dangerous Waters—Buoyancy Matters!

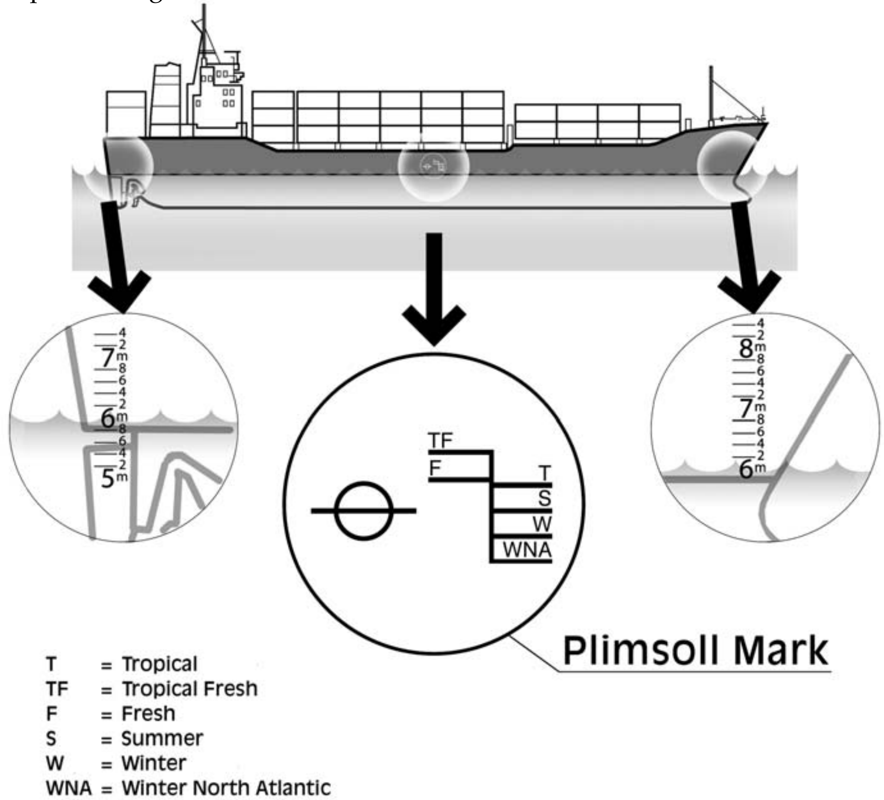
California's bays and harbors can be treacherous places for container ships and oil tankers with heavy loads. Why? These ships go great distances, from the tropics to the arctic, sometimes all in one trip. Due to the expense, harbors and bays are often dredged to just a certain depth to accomodate big ships, and not an inch more. Also, depending on tides, underwater features such as rocks and sand bars become obstacles to avoid. If a ship is loaded in a salt water port, say, in Japan, and then comes across the ocean to unload in a fresh water port, such as the San Joaquin Delta, they could run into serious problems if the ship was loaded too heavily at the beginning. Ships can run aground, spill their cargo, or even worse, break a hole in the hull and leak fuel and oil. How do captains of these ships know when their ships are properly loaded? It has been an issue since the seas were first sailed, and, luckily, someone had a plan.

Samuel Plimsoll (1824-1898) was a member of the British Parliment. Plimsoll was concerned with the loss of ships and crews due to overloading. He called them "coffin ships." To save sailors' lives, he persuaded Parliament to amend the 1871 Merchant Shipping Act to provide for the marking of a line on a ship's sides that would disappear below the water line if the ship was overloaded. Samuel Plimsoll developed the Plimsoll Mark now used by the shipping industry internationally.

The Plimsoll Mark is a reference mark located on the midship of a vessel hull indicating the depth to which it can be loaded, depending upon the destination and the route. The Plimsoll Mark evolved into internationally recognized load lines. Load lines show the maximum draft (in terms of the amount of freeboard, or distance from the waterline to the main deck) to which the vessel may load in different zones and seasons around the world. Draft marks are indicated in meters and are at the forward, midship, and aft of the ship. The Plimsoll Mark is located midship only.

The difference in salinity between loading a ship in fresh water and then proceeding to sea causes an increase in freeboard of about 8.5 inches, called the FWA (fresh water allowance). The ship will rise in the salt water that much or sink that much if proceeding from sea to a fresh water dock. The actual FWA is a little different for each situation, and calculations used by computers on ships are much more exacting. The calculations use the actual water density, displacement of the ship, and other factors that take into account the shape of the vessel.

Next time you see a container ship or an oil tanker, look for the Plimsoll Mark and draft lines. Is the ship in fresh water or salt water? Is it safely loaded? Now you'll know!



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Activity 8.2
You Are What You Eat: Plastics and Marine Life

Just because you can't see it doesn't mean it isn't there. Whether it sinks or floats, plastics in the sea spell trouble for all the animals in the ocean. Find out the many ways marine life can be affected by plastics in their aquatic home.

Background

Many animals that live in the ocean come into contact with discarded plastic. Because this plastic is not natural to their environment, the animals don't recognize it or know what to do about it. They encounter plastics most often as a result of their feeding behavior. Often they get entangled in it, are cut and injured, or think it's food and try to eat it. The number of marine mammals that die each year due to ingestion and entanglement approaches 100,000 in the North Pacific Ocean alone (Wallace, 1985). Worldwide, 82 of 144 bird species examined contained small debris in their stomachs, and in many species the incidence of ingestion exceeds 80% of the individuals (Ryan 1990).

Plastics and Marine Life

The potential for ingestion of plastic particles by open ocean filter feeders was assessed by the Algalita Marine Research Foundation by measuring the relative abundance (number of pieces) and mass of floating plastic and zooplankton near the central high-pressure area of the North Pacific central gyre. (The gyre is a large recirculating area of water halfway between Los Angeles and Hawaii.) Plankton abundance was approximately five times higher than that of plastic, but the mass of plastic was approximately six times that of plankton. This area is far from land, and many types of marine life feed here.

Plastics don't go away, they just go somewhere else where we can't see them. The effects on marine life can be devastating. Aquatic animals may be harmed by plastic objects in a variety of ways, depending on the shape and buoyancy of the object. These animals may suffer injury or even death from their encounters with plastics. Animals can be harmed through entanglement, laceration, suffocation, and ingestion.

The buoyant properties of water allow some plastics to float, some to sink, and some to stay in the water column. The types of plastics marine animals may come into contact with depend upon where they live and eat: at the water's surface, its bottom, or floating in the water column between the surface and the bottom. All we can see are the plastics on the surface, but there are many different varieties and shapes of plastic objects below the surface. Because we can't see this pollution, we may forget that it exists. Marine animals know by first hand experience the devastating effects of plastics pollution in the ocean, but they aren't talking. As cities grow and more plastics are produced and enter the marine environment, marine species will continue to be affected unless we make wise choices regarding plastic use and disposal.

Science skills

- Predicting
- Analyzing
- Deducting
- Charting

Concepts

- Plastics in the ocean affect animals that live there through entanglement, laceration, suffocation, and ingestion.
- Different plastics have different buoyancies, so where and what a marine organism eats determines the type of plastics to which it will be exposed.

California Science Content Standards

8. All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept, students know:
8.c. The buoyant force on an object in a fluid is an upward force equal to the weight of the fluid the object has displaced.
8.d. How to predict whether an object will float or sink.

Objectives

Students will:

- Understand that different types of plastics float, sink, or stay neutrally buoyant.
- Learn where ten marine species feed in the water column.
- Make connections between where a marine organism lives and feeds and the types of debris to which it is exposed.

Time to complete

One hour, including video

Mode of instruction

Watch video, then group or individual work with worksheet, chart, and cards, followed by presentation of results and whole class discussion.

Materials

1. Video—*Synthetic Sea: Plastics in the Ocean.* Borrow from California Coastal Commission education web site: *www.coastforyou.org*
2. "You Are What You Eat" worksheet
3. "Marine Animal Feeding Habits and Plastic Risk" chart
4. "Marine Animal Cards"
5. "Plastics and Their Uses" handout

Activity

1. Watch the video *Synthetic Sea: Plastics in the Ocean* with your class. Conduct a whole class discussion on what students think about plastics in the ocean. Does plastic just go away? What types of animals are most affected?

2. Next, conduct a whole class discussion on the many ways we use plastics in our daily lives.

3. Hand out "Plastics and Their Uses" and discuss the different types of plastics. Note that most cities only accept SPI 1 and 2 for recycling; though many of the other types of plastic are labeled as "recyclable," in reality, this does not occur and the majority of plastics end up in landfills.

4. From water bottles to computers, we rely on the convenience and availability of plastics to provide many of today's necessities. List on the board the shapes that plastic can come in, and have students give examples of what they are used for:
One-dimensional objects (line, rope, strapping bands)
Two-dimensional objects (sheets, bags)
Reticulated (netting, six-pack rings)
Hollow-bodied (bottles, fishing floats)
Small particles (Styrofoam, pellets used in making plastic objects)
Angular (boxes, crates)

5. Discuss the marine zones in which animals feed (surface, pelagic, and benthic). Have students brainstorm what types of animals might live and feed in each of these zones.

6. Either divide the class into small groups (3-4 students) or distribute materials to individuals. Distribute copies of the "You Are What You Eat" worksheet, "Marine Animal Feeding Habits and Plastic Risk" chart, and the "Marine Animal Cards" to groups or individuals.

7. Have students complete the worksheet activity. Keep in mind that there are many different possible "right" answers. What is important is that students have a rationale for their choices.

Results and reflection

1. After the groups or individuals have completed the activity, draw the chart on the board. Have each group or student choose one form of plastic (i.e., one-dimensional, two-dimensional, small particles, etc.) and present to the class their results and rationale of what species would be most affected.
2. Allow time to propose different answers, discuss them, and wrestle with different conclusions.
3. Conduct a whole class discussion on how to reduce the amount of plastics in the marine environment. (Refer to activity CA1: Marine Debris, It's Everywhere! for waste reduction ideas.)

Preparation

Order video *Synthetic Seas: Plastics in the Ocean* two to three weeks in advance. Photocopy worksheet, chart, cards, and table, one per student.

Outline

Before class

1. Order video *Synthetic Seas: Plastics in the Ocean* two to three weeks in advance of lesson from California Coastal Commission education web site, *www.coastforyou.org*.
2. Photocopy "You Are What You Eat" worksheet and "Marine Animal Feeding Habits and Plastic Risk" table, one for each student or group.
3. Photocopy and cut out "Marine Animal Cards," one set per student.
4. Photocopy "Plastics and Their Uses," one per student.

During class

1. Lead whole class discussion on characteristics of plastics in the oceans.
2. If working in groups, divide students into groups of 3-4.
3. Hand out worksheets, chart, and cards: students will arrange cards at their own tables.
4. Table groups or individuals present rationales and results to class.

Conclusions

Marine organisms are besieged with plastics in their aquatic home. They can mistake plastic pieces as food and ingest them, or become accidentally trapped by plastic marine debris.

Extensions and applications

1. Have students bring from home different types of plastic trash, or use the trash from their lunches. Conduct buoyancy experiments to see which pieces float and which sink, and which are neutrally buoyant. Group like objects together based on buoyancy. Now check their recycle number on the bottom—the number in the triangle. Do all types of plastic with the same number have the same buoyancy? What might affect the buoyancy besides the type of plastic (e.g. the shape of the object).
2. Get a list from your local refuse agency that indicates what plastics they accept for recycling, and sort your plastic trash from #1 above accordingly. Are the recyclable plastics primarily floaters or sinkers? Do you think that the plastic that is more easily recyclable ends up in the ocean less often than those that are not recyclable in your area? Which ocean animals might recycling plastic help most?

Adapted from

Animals' Feeding Ranges and Plastics, *Plastics Eliminators: Protecting California Shorelines.* California Aquatic Science Education Consortium. CASEC c/o 4-H series, Loran Hoffman, Department of Human and Community Development, UC Davis, 1 Shields Ave., Davis, CA 95616. *www.rain.org/casec*

Further references on ocean pollution:
www.coastal.ca.gov/publiced/marinedebris.html
www.marinedebris.noaa.gov
www.epa.gov/owow/oceans.debris
www.oceanservice.noaa.gov/education/kits/pollution/welcome.html

Answer Key: Marine Animal Feeding Habits and Plastic Risk*

	One dimensional	Two dimensional	Reticulated	Hollow	Small	Angular
Surface Feeders	6	6	9	7	3,7,9	
Pelagic Feeders	4,5	6,8	4, 8	1,2,4,5	10	2
Benthic Feeders	4	6	2	2	10	2

**Note: These are some possible answers. Your students may have additional answers with plausible rationales. This is an area of active scientific investigation; we have yet to learn the extent of devastation caused by plastic marine debris.*

You Are What You Eat

Do different forms of plastic affect animals feeding in different parts of the ocean? Here is some information that will help you answer this question and fill out your Marine Animal Feeding Habits and Plastic Risk chart.

The Three Marine Zones

Scientists divide bodies of water into three basic areas:

1. ***The surface zone:*** the very surface of the water where it meets the air and things float where you can see them.

2. ***The pelagic zone:*** the open water below the surface where neutrally buoyant fish swim and plankton float.

3. ***The benthic zone:*** what lies beneath the bottom of the of water; consists of mud, sand, or rock.

Where Marine Life Eats

Different forms of marine life gather their food in different zones. For example, some birds are surface feeders. They skim along just above the ocean's surface, and scoop up small bits of floating fish. Many fish are pelagic feeders. They swim about, eating smaller animals, plankton, and other food that share the water with them. Many whales, turtles, seals, and diving birds are pelagic feeders. Other kinds of fish, turtles, whales, and sea otters swim along the bottom to scoop up food from the ocean floor. They are called benthic feeders.

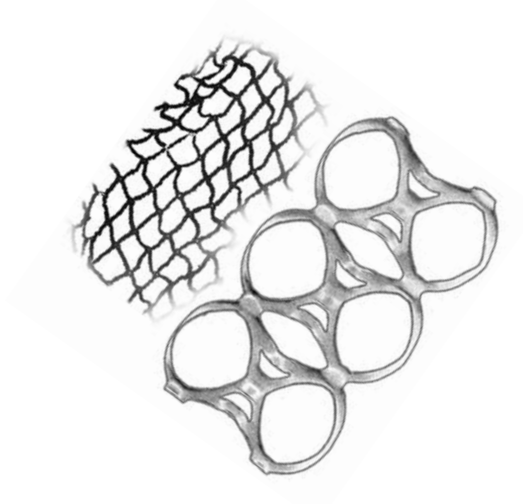
Animals that feed in different areas of the ocean often interact with different forms of plastic. For example, a bird skimming the ocean surface might accidentally scoop up bits of floating plastic pellets thinking they were food, but wouldn't scoop up a large, floating, angular object such as a Styrofoam ice chest, or a hollow object such as a plastic bottle.

Activity Directions

1. Arrange each card in your packet on the chart so that the animals are:
   - located under the form of plastic they will have trouble with and,
   - next to the zone where they feed

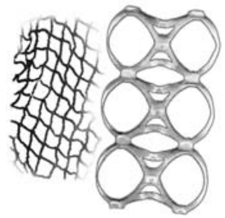
2. Then, take the card off of the square and write the animal's name in the square. One animal may be affected by more than one type of plastic, and may feed in more than one habitat, so there will likely be more than one animal name in a square.

3. You will compare charts with other students. Be sure to be able to explain your rationale for placement.



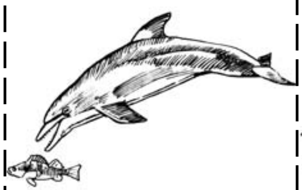
For use with Activity 8.2: You Are What You Eat

Marine Animal Feeding Habits and Plastic Risk

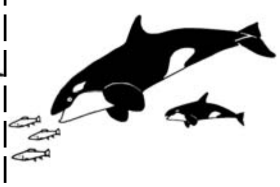
	One-dimensional Objects 	Two-dimensional Objects 	Reticulated Objects 	Hollow Objects 	Small Particles 	Angular Objects 
Surface Feeders						
Pelagic Feeders						
Benthic Feeders						

You Are What You Eat Marine Animal Cards

Photocopy and cut along dotted lines.
Each student receives one complete set.



1. Bottlenose dolphin: feeds on surfperch in open water below surface, grabs with teeth.

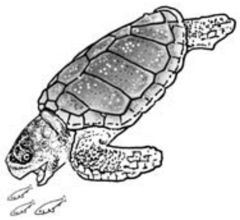


2. Orca: eats fish and marine mammals, grabs with teeth. Feeds in open water below surface.

3. Gull: eats fish, inter-tidal organisms, beach debris. Feeds on shore, top of water, grabs food with beak.

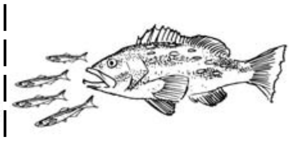
4. Sperm whale: eats squid and fish below surface. Grabs food with long, narrow mouth.

5. Common dolphin: feeds below surface in open water. Grabs small squid, other small fish with teeth.



6. Loggerhead sea turtle: eats jellies, fish, mussels, clams, crabs; grabs them with toothless mouth.

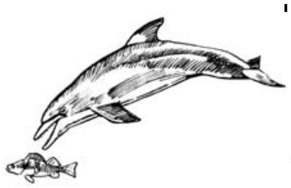
7. Elegant tern: feeds on anchovies and other fish, floats or dives shallowly into the water.



8. Sea bass: feeds below surface in open water, sucks herring, krill, and anchovies into its large mouth.

9. Forster's tern: feeds on various small fish floats along or dive shallowly into water.

10. Sea otter: feeds on benthic urchins and shellfish, bringing them to the surface to eat.



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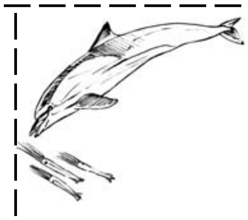

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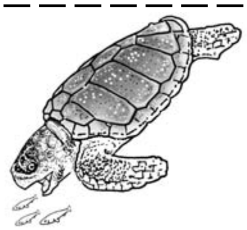

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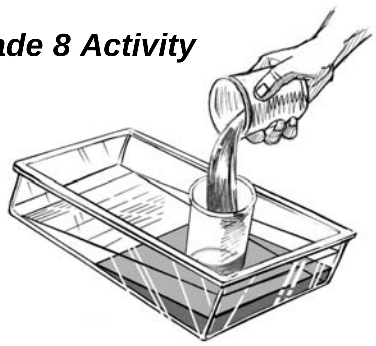
Plastics and Their Uses

Name	SPI Code	Description	Uses
PET (Polyethylene terephthalate)	1	High strength; transparent; barrier to gas and moisture, resistant to heat; **sinks in water**.	Plastic soft drink and water bottles, beer bottles, mouthwash bottles, peanut butter and salad dressing containers, ovenable pre-prepared food trays.
HDPE (High density polyethylene)	2	Tough; chemical and moisture resistant; permeability to gas; translucent or opaque matte finish; **floats in water**.	Milk, water and juice containers, trash and retail bags, liquid detergent bottles, yogurt and margarine tubs, cereal box liners.
PVC (Polyvinyl chloride)	3	Hardy; chemical resistant; resistant to grease/oil; transparent, translucent or opaque; **sinks in water**.	Clear food packaging, shampoo bottles, medical tubing, wire and cable insulation.
LDPE (Low density polyethylene)	4	Tough; lightweight; barrier to moisture; can be nearly transparent or opaque; low to high gloss; **floats in water**.	Bread bags, frozen food bags, squeezable bottles, fiber, tote bags, bottles, clothing, furniture, carpet.
PP (Polypropylene)	5	Hard; resistant to chemicals; resistant to heat; barrier to moisture; resistant to grease/oil; transparent, translucent, or opaque; **floats in water**.	Ketchup bottles, yogurt containers and margarine tubs, medicine bottles
PS (Polystyrene)	6	Stiff; transparent or opaque; smooth surface; **sinks in water.**	Compact disc jackets, aspirin bottles.
EPS (Expanded polystyrene)	6	Lightweight; heat resistant; insulating; opaque; foamed**; floats in water.**	Food service applications, grocery store meat trays, egg cartons, cups, plates.

Grade 8 Activity



Science skills
- Observing
- Experimenting
- Hypothesizing
- Communicating

Concepts
- In tidal estuaries, fresh water behaves differently from salt water due to differences in density of the waters.
- This difference in density is the engine that drives tidal wedges.

California Science Content Standards
8. All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept, students know:
8.a. Density is mass per unit volume.
8.d. How to predict whether an object will float or sink.

Objectives
- Students will demonstrate why fresh water will stay at the surface while salt water will travel up a river along the bottom in a wedge because of density differences.
- Students will describe the characteristics of water in an estuary, from salty ocean water, to brackish, to fresh water.

Time to complete
One-half to one hour

Mode of instruction
Students experiment with a hands-on model and complete a worksheet, followed by a whole class discussion.

Activity 8.3
The Edge of the Wedge

Fresh water out, salt water in—the turn of the tides in coastal estuaries makes for a mixing adventure.

Background

An estuary is a semi enclosed part of the coastal ocean where fresh water from land mixes with seawater. Historically, because of ease of transport by water, cities have been located on rivers and estuaries; seven of the ten largest U.S. cities are on large estuaries. San Francisco Bay is one of the smaller major estuaries at 1,190 square kilometers (459 square miles). The Chesapeake Bay system is the largest in the U.S., covering over 12,000 square kilometers (4,633 square miles). Estuaries are rich in nutrients that support large phytoplankton populations, which in turn provide food for zooplankton, fish, benthic organisms, and birds. Estuaries play a major role in the productivity of the coastal ocean, serving as home, nursery, and breeding ground for many species.

Estuaries act as a two-way street for water movement, where fresh water flows from the river into the estuary and spreads out as a layer over the denser salt water, while the salt water comes in with the tides. Fresh water moves generally seaward in the surface layer, and the two layers are separated by a horizontal pycnocline zone, which is a zone where water density changes noticeably with increasing depth as a result of changes in either salinity or temperature: low density surface water cannot readily move downward through the pycnocline zone. Friction occurs between the seaward-moving surface layer of fresh water and the salt water below it, causing currents that drag salt water from below and incorporate it into the surface layer. Because of the upward movement of salt water into the surface layer, the salinity of the surface layer increases in a seaward direction. The subsurface salt water in an estuary forms a wedge with its thin end pointed upstream. This is an idealized version—depending on the flow of the river and the time of the year, an estuary may be only moderately stratified. In general, the greater the flow of the river, the greater the degree of stratification, such as the lower Mississippi River or the Columbia River during flood stages.

Activity

1. Earlier in the day, prepare or have students prepare a salt water solution: add 35 grams of sea salt (regular salt has additives) to one liter of warm water, or approximately 1.2 ounces (2 scant tablespoons) of salt to 1 quart of warm water. Mix thoroughly until all salt is dissolved. Tint the salt water with food coloring (red makes a dramatic statement). Allow water to come to room temperature. To make a brackish mixture, halve the amount of salt (however, the zonation will not be quite as dramatic).

Materials

Photocopy of "Edge of the Wedge Lab" worksheet, one for each student.

For each group of 3-4 students:

1. Large, clear waterproof box or deep pan, such as a 9" x 13" baking dish
2. Tap water
3. One quart room temperature salt water (see activity description for directions on how to prepare; sea salt and food coloring are needed)
4. White paper
5. Paper cup
6. Small stones or pebbles

Preparation

Collect materials. Photocopy worksheet. Prepare area for a possibly wet model (not neccesarily, but spills may occur). Mix salt water.

Outline

Before class

1. Collect materials for model.
2. Photocopy "Edge of the Wedge Lab" worksheet, one for each student.
3. Mix salt water and food coloring.

During class

1. Student groups build model and conduct experiment.
2. Classroom discussion on experimental results.
3. Classroom discussion relating the experimental results to tidal wedge dynamics in estuaries.

2. Divide class into groups of three or four to a model. Hand out worksheets and model materials to students. Go over the worksheets and answer questions. Be sure they understand the experimental procedure before they begin.

Results and reflection

1. In a whole class discussion, students share their hypotheses, observations, and conclusions with the class.
2. Conduct a whole class discussion on tidal wedges and density differences in salt water and fresh water.
3. Ask students how they could create a control for this experiment. How do we know that the food coloring is not responsible for the result? Have one or more groups replicate the exercise with colored fresh water (instead of colored salt water). Observe the difference in the result when fresh water is added to fresh water instead of salt water being added to fresh water.

Conclusions

Density differences between salt water and fresh water create stratification within the water column.

Extensions and applications

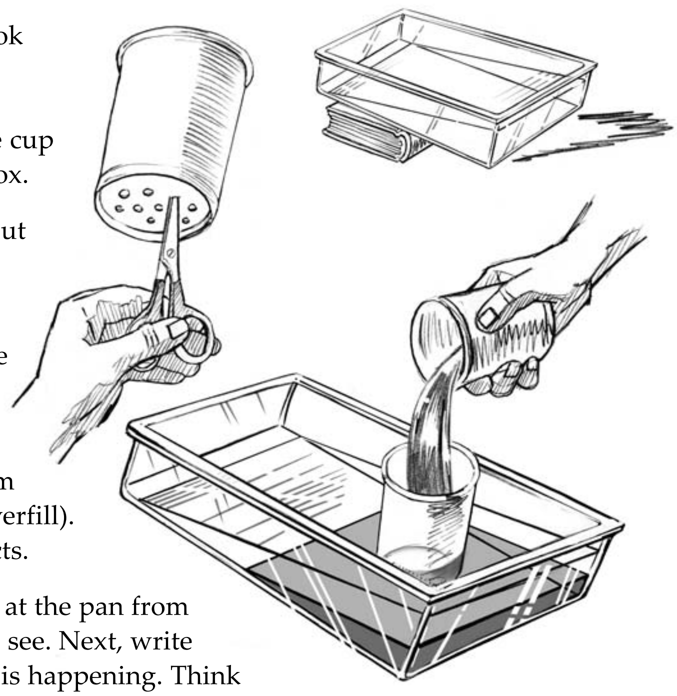
1. How would tides influence the tidal wedge process?
2. Would the tidal influence be stronger in a fast flowing or slow flowing river?
3. Students may conduct research on a large California river that enters into the ocean. Does it have a strong tidal wedge? What types of organisms live there, and how have they adapted to the changing salinities? Have the dynamics changed over the years? What has contributed to the changes?

Adapted from

A Raindrop Journey, by Barbara S. Waters, 1998. *Massachusetts Bays Watershed Stewardship Guide*. Massachusetts Executive Office of Environmental Affairs, Massachusetts Bays Program.

Edge of the Wedge Lab

A. Make the salt water wedge model



1. Place one end of the clear box or pan on a small block or book about 1 inch high.

2. Make several tiny holes in the bottom of the cup. Weight the cup with small stones and place at the lower (deeper) end of the box.

3. Pour room temperature tap water into the box until it is about 1/2 inch from the top of the pan. Wait for about 3 minutes to allow the water to settle.

4. While waiting for the water to settle, take a moment to write a hypothesis about what will happen when you add the colored salt water to the cup.

5. Taking turns in your group, slowly and gently pour the room temperature salt water into the cup a little at a time (do not overfill). Observe. Only use enough water to be able to observe the effects.

6. After you have added the salt water, get down low and look at the pan from the side (instead of from the top). Draw a diagram of what you see. Next, write down a description of what you observe, and conclude why it is happening. Think about what the model represents and where this phenomenon would occur in nature.

B. Experimental Process

1. **Hypothesis**: What will happen when you add the salt water to the cup in the model?

2. **Method**: Describe only **how** you added the salt water to the cup in the model. Include any possible variables (e.g., the rate at which you poured in the water, the angle of the pan, etc.).

3. **Results**: Describe only **what you observed** in the model when you added the salt water to the cup. On the back of this page, draw a diagram to help explain what you saw. Do not write about your hypothesis here; save your ideas for the analysis.

4.**Analysis**: using as few words as possible, **explain your results**. Is your hypothesis proved or disproved by your observed results?

5. **Discussion:** Here is the chance to be more creative. Discuss what you would do differently next time you conduct this experiment. Do you think this was a good model? How could the model be improved? How could the model better show what happens in nature? Use back of page for your answer.

Notes

Chapter 9
Community Action Activities

One way to tackle to environmental problems is through community action. Once your students have learned of their precious heritage, California's natural resources and wealth of habitats and species, they will be inspired to become a part of the community that seeks to preserve and protect it from the pressures of our state's growing population. These activities can be adapted for all grades, from elementary to high school. To gain the most educational value from these community action activities, we suggest you conduct them in sequence.

Community action is a great way to tie abstract classroom lessons into a student's life outside the school walls. In school, she or he will learn about where environmental problems exist and from where they originate—the stories of how wildlife is harmed can be illuminating yet discouraging. The best antidote to discouragement is action! A student will feel empowered when she or he knows that there is always something that can be done to combat marine pollution and habitat loss. The activities in this section include suggestions that a student can implement at home as well as in the community.

The activity CA3: *Clean Shorelines, Clean Oceans* can be a part of the annual Coastal Cleanup Day (the third Saturday in September), or a part of the Coastal Commission's year-round Adopt-A-Beach program. You may also clean up a creek, river, or lake shore.

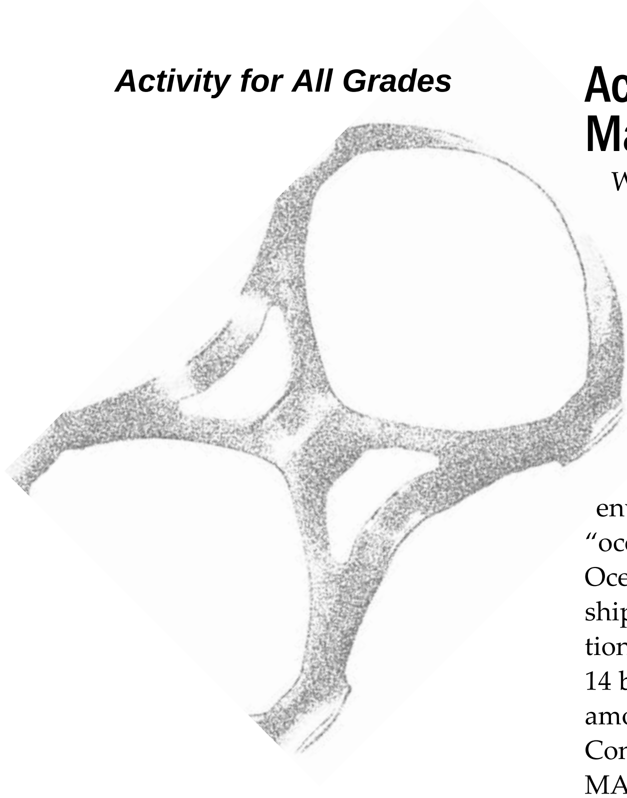
Coastal Cleanup Day is the largest volunteer event focused on the marine environment in the state. Between 1985 and 2006, over 750,000 Californians removed more than 12 million pounds of debris from our state's shorelines and coast. The event is part of the International Coastal Cleanup, organized by The Ocean Conservancy. Between 1986 and 2005, six million people from all 55 U.S. states and territories and 118 countries have participated in the event, removing more than 100 million pounds of debris and cleaning more than 170,000 miles of coastline.

The Coastal Commissions' Adopt-A-Beach program can be done at any time. When a group "adopts" a beach, they commit to cleaning it at least three times per year, although school groups can fulfill their obligation with a single cleanup.

If your class is unable to participate in a field trip activity, then the CA1: *Marine Debris—It's Everywhere*, CA2: *Searching Out Nonpoint Sources of Pollution*, and CA4: *Preventing Pollution at the Source* are still valuable activities that have community service extensions. And remember, trash in our communities could eventually reach the ocean, so cleaning up your schoolyard or neighborhood park can make a difference.

To find out more about California Coastal Cleanup Day, the Adopt-A-Beach Program and other programs available to educators through the California Coastal Commission, visit *www.coastforyou.org*, call (800) Coast-4U, or email *coast4u@coastal.ca.gov*.

Activity for All Grades



Science skills

- Analyzing
- Evaluating
- Predicting
- Problem solving

Concepts

- Marine debris harms ocean wildlife.
- Our actions contribute to marine debris.
- We can make a difference in the amount of marine debris in the oceans by conducting a beach cleanup and by changing some of our trash habits.

Objectives

Students will:

- Understand what marine debris is and from where it comes.
- Describe the hazardous effects of marine debris on marine wildlife.
- Consider solutions to problems associated with marine debris.

Time to complete

50 minutes

Activity CA1
Marine Debris: It's Everywhere!

What is marine debris—where does it come from, and where does it go? Find out the sources and figure out some solutions to one of our ocean's most pervasive problems.

Background

Marine debris is trash found in the ocean or along its shores. From the sandwich wrapper left on the playground that's washed into the gutter leading to an ocean outfall, to the cigarette butt a smoker left in the sand, it's all trash that ends up in the ocean environment. The source of marine debris can be classified as either "ocean-based" or "land-based" depending on where it enters the water. Ocean-based marine debris is waste that is disposed of in the ocean by ships, recreational boats, and petroleum rigs and platforms. The National Academy of Sciences estimates that ocean sources once dumped 14 billion pounds of garbage into the ocean every year! While the amount of ocean dumping has been curtailed due to the International Convention for the Prevention of Pollution from Ships, known as MARPOL 73/78 (MARine POLlution), illegal dumping continues to contribute to the marine debris problem.

Land-based debris, on the other hand, is debris that blows, washes, or is discharged into the water from land. Studies estimate that about two-thirds of marine debris enters the water from land. Contributors include recreational beach users, people who drop litter on sidewalks and streets, plastics manufacturers and transporters, inadequate sewage treatment operations, and illegal dumping. It is important to remember that land-based garbage has the potential to become marine debris. People don't often realize that garbage they produce in their homes and communities can reach the ocean via storm drains, sewer systems, streams, and rivers.

Besides the fact that trash on beaches and in oceans looks ugly, why should we be concerned with marine debris? For one reason, dirty beaches reduce tourism in the area and subsequently tourist revenue, so communities are forced to spend millions of dollars each year to clean their beaches. Marine debris is also dangerous to beach visitors and scuba divers. Beach visitors have required stitches from stepping on broken pieces of glass and metal buried in the sand, and scuba divers have become entangled in lost fishing gear.

Marine debris not only harms humans, it can be fatal to marine wildlife. Marine mammals, sea turtles, birds, and fish can become entangled in plastic fishing line, plastic strapping bands, six-pack rings, and other plastic trash. Once entangled, they may spend energy trying to get free, may become sick or weak, and even die. Certain marine animals can also mistake plastic debris for food and may die as a result of eating it. Sea turtles mistake plastic bags for their favorite food, jellies, and birds mistake small pieces of plastic for fish eggs. Humans are responsible for

Mode of instruction
Students watch the *International Coastal Cleanup* slide show and afterward discuss the various sources of marine debris. Next, conduct a whole class discussion on waste reduction as one solution to the problem.

Materials
1. *International Coastal Cleanup* slide show (order from *www.oceanconservancy.org*)
2. One 3" x 5" card for each student

Preparation
Three weeks in advance, order *International Coastal Cleanup* slideshow from:
www.oceanconservancy.org
cleanup@oceanconservancy.org
(202) 429-5609
Director of Publications
The Ocean Conservancy
1725 De Sales Street, NW, #600
Washington, DC 20036

Outline
Before class
Order Coastal Cleanup slideshow

During class
Whole class discussion on marine debris and waste reduction methods.

the destruction caused by marine debris and it is up to us to bring the destruction to an end.

What can we as individuals do to help solve the hazardous problem of marine debris? We can participate in a beach cleanup. We can also rethink some of our habits, and reduce, reuse, and recycle trash—all trash is potential marine debris.

Activity
1. Begin by asking what your students know about marine debris. What is it, where does it come from, who is responsible for it, and how does it affect our lives? How does it affect marine life? Put some of the student answers on the blackboard to refer to later.

2. Present the *International Coastal Cleanup* slide show. Hold a whole class discussion on the sources of marine debris. Questions can include: How does marine debris reach the oceans? What are some additional land-based sources? What happens to all the trash they throw away? What is "away?" How can this trash become marine debris? What about litter that they see in the streets and on the school grounds? *(Pipes connected to storm drains often carry runoff storm water from streets directly to nearby bodies of water such as streams, rivers, and oceans. Consequently, they transport street litter to the nearest body of water as well.)*

3. Now discuss with your students how they can become part of the solution instead of part of the problem. What can they do to decrease the amount of debris ending up on the beach and in the ocean? Write the solutions on the blackboard. *They can rethink purchasing a product that is poorly packaged; reduce, reuse, and recycle trash; and remember that every choice they make can make a difference.* What kinds of trash are recyclable? Do any of the students recycle regularly? What about non-recyclable trash—can these items be reused or can our use of them be reduced?

4. Make a Reduce, Reuse, Recycle, Remember table on the board. Ask students for their ideas on specific actions they can take to reduce the amount of waste they produce. Here are some suggestions to get started. See if your students can add to this list.

Reduce

Use a sponge instead of paper towels; use metal utensils, a glass, or a plate instead of paper cups and plates and plastic utensils; write on both sides of paper; bring a canvas bag to the store instead of accepting a paper or plastic one; share items with friends and family and use the library; buy products with less packaging—one-third of our garbage is packaging! If you don't really need something, don't buy it!

Reuse

Use a lunch sack for more than one day; bring lunch in reusable containers; reuse bags from the store; use containers such as shoe boxes and margarine tubs for storage; donate items to charities and thrift stores when you're done using them.

Recycle

Newspapers, bottles, aluminum cans, car batteries, paint, automotive fluids, and plastic bottles. Complete the recycling loop and buy recycled products.

Remember

We can all make a difference!

5. Emphasize that in taking these actions, students can help solve the problem of marine debris. Encourage students to implement these waste reduction methods at school and at home. Encourage them to share these ideas with their families.

Results and reflection

Students write a one-page summary on the sources and effects of marine debris, and what they can do to help reduce the problem.

Conclusions

It's never too late to do something for the oceans. Rethinking our use of everyday products can make a difference to the creatures that depend upon clean oceans and beaches for survival.

Extensions and applications

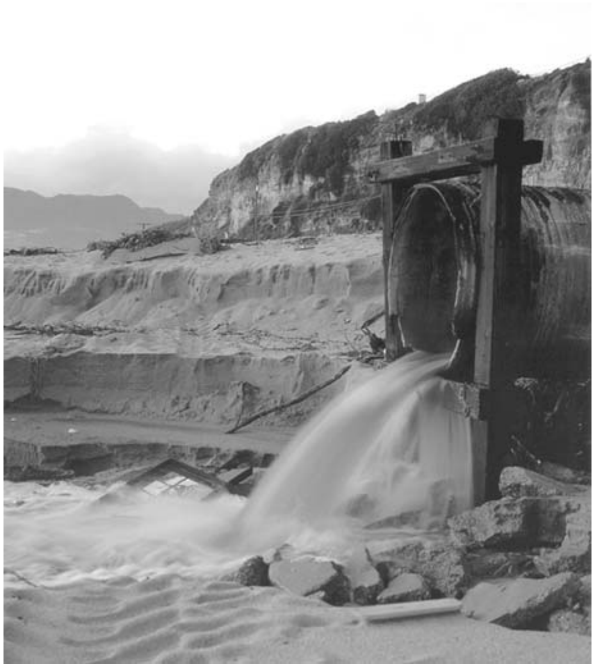
1. Design and conduct a survey of local boaters and fishers to find out how they handle their trash.
2. Design an informative handout or pamphlet about marine debris using photographs of marine wildlife and marine debris.

Adapted from

Save Our Seas, A Curriculum for Kindergarten through Twelfth grades. The Ocean Conservancy (formerly known as Center for Marine Conservation) and California Coastal Commission, 1993.

Activity CA2
Searching Out Nonpoint Sources of Pollution

What is it, and what can you do to stop it?



Science skills
Map reading

Concepts
Nonpoint source pollution is a major problem to marine life. The good news is that each of us can be part of the solution.

Objectives
Students will identify nonpoint source pollution and how it affects both water quality and water organisms.
Students will understand how consumer choices can reduce nonpoint source pollution.

Time to complete
50 minutes

Background

Land-based marine pollution can either be from a "point source" or a "nonpoint source." Point source pollution originates from a specific place such as an oil refinery or a paper mill. Nonpoint source pollution, on the other hand, is contaminated runoff originating from an indefinite or undefined place, often a variety of places (e.g., farms, city streets and parking lots, yards and landscaping, construction sites, and logging operations). The soot, dust, oil, animal wastes, litter, sand, salt, pesticides and other chemicals that constitute nonpoint source pollution often come from everyday activities such as fertilizing lawns, walking pets, changing motor oil, and driving. With each rainfall, pollutants from these activities are washed from lawns and streets into stormdrains that often lead directly to nearby bodies of water such as streams, rivers, and oceans.

While rarely visible, nonpoint source pollution is a chronic and ubiquitous form of coastal water contamination. The U.S. Environmental Protection Agency estimates that the primary cause of the pollutants in the ocean are not from point sources, but from various forms of contaminated runoff. The table on page 129 outlines examples of nonpoint source pollutants, their sources, and their effects.

Finding solutions to nonpoint source pollution is difficult, even if the sources can be identified and located. Often solutions involve major changes in land-use practices at the local level and expensive methods to minimize runoff. However, nonpoint source pollution does offer individual citizens an ideal opportunity for combating marine pollution. There are actions we can take every day that can help—by changing some of our habits, we can help reduce nonpoint source pollution. The first step is understanding what some of the common types of pollutants are that we put in the ocean every day. The next step is to look for alternatives to use in place of those pollutants. Using these alternatives, we can still have clean houses and luxuriant yards—and a healthy ocean!

Activity

1. Ask students what they know about nonpoint source pollution, and write their answers on the board. Have they heard of the term? Do they know what it means? What are some examples? (*Nonpoint source pollution is contaminated runoff originating from an indefinite or undefined place, often a variety of places, see list above.)*

Mode of instruction

Students study a local map to identify possible sources of nonpoint source pollution, followed by a classroom discussion on actions students can take to reduce nonpoint source pollution.

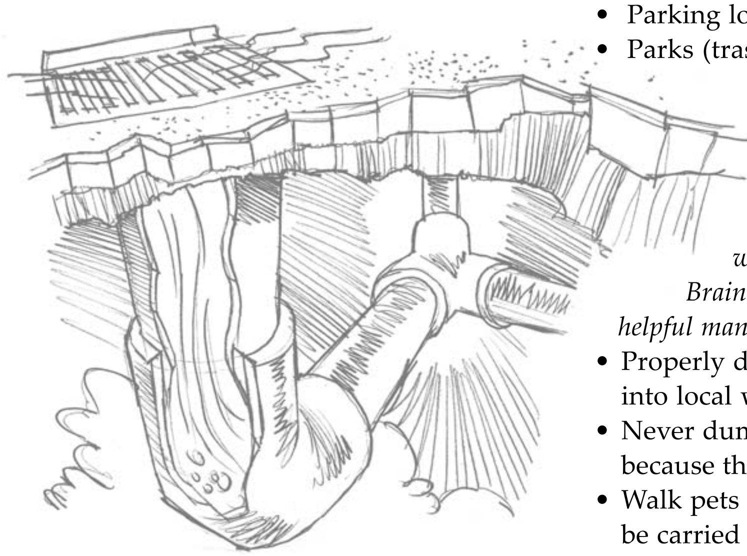
Materials

1. Local map of the community, photocopied for each student
2. Map of community's storm drain system from the local Department of Public Works (optional)
3. "Nonpoint Source Pollution" and "Safe Substitutes" handouts

Preparation

Contact your local Department of Public Works to get map of storm drains. Find map of local community that includes waterways. Photocopy maps and information sheets.

Outline



Before class

1. Photocopy maps of storm drains and local community, one for each student.
2. Photocopy "Nonpoint Source Pollution" and "Safe Substitutes" (one page, double-sided) for students to read and take home.

During class

1. Hand out maps for whole class discussion.
2. Hand out "Nonpoint Source Pollutants" and "Safe Substitutes" information sheets.

2. Next, ask students what types of nonpoint source pollution they think could be originating from their school and their community. Write this on the board.

3. Pass out the "Nonpoint Source Pollutants" and "Safe Substitutes" handout. Go over the list as a group.

4. Pass out a copy of a map of your community. Each student will now study the map and locate possible sources of nonpoint source pollution in your community. Some examples could include:

Schools

- Playground, football field (trash, fertilizers, pesticides)
- Sewage system, including restrooms, cafeteria, science classes (trash, excess nutrients, detergents, chemicals, pathogens)
- Parking lot (trash, heavy metals, dripping oil)
- Sidewalks and outdoor hallways (trash)

Community

- Farmland (sediments, excess nutrients, fertilizers, pesticides)
- Construction sites (trash, sediments)
- Residential areas (trash, fertilizers, pesticides, detergents from car washing)
- Parking lots (trash, heavy metals, dripping oil)
- Parks (trash, fertilizers, pesticides, animal waste)

5. Brainstorm with students about actions they *or their parents and caregivers* can take to reduce pollutants entering the marine environment. (*Note: Many of these are activities that adults would likely undertake; students would need to advocate these suggestions to their parents. Brainstorm with your students how they can approach adults in a helpful manner.*) Ideas could include:

- Properly dispose of trash in garbage cans. Storm drains empty into local waterways and can carry litter.
- Never dump chemicals on the ground or down storm drains because they may end up in the local stream, river, or bay.
- Walk pets in grassy areas or parks. Pet wastes on pavement can be carried into streams by storm water. Pick up after your pets.
- Do not pour chemicals down drains or toilets because they may not be removed in sewage treatment and can end up contaminating coastal waters. Use non-hazardous alternatives whenever possible (see "Safe Substitutes," page 130).
- Keep cars well maintained and free of leaks. Recycle used motor oil (contact local public works department or call (800) CLEANUP, for how to store and where to take waste oil).
- Don't dispose of leaves or grass clippings in your storm drain. Remember, storm drains usually lead to a body of water, and excess nutrients are a type of pollution. Instead, try composting yard waste.
- Landscape your yard to prevent runoff. Use as few pesticides as possible. Try "natural" (non-toxic) approaches to pest control wherever possible and use organic gardening techniques.

Results and reflection

1. Students locate their homes or neighborhoods on the maps. Then, draw on maps with a colored pencil or crayon the nonpoint source pollution originating from their homes and community, and track where it may go. Does it empty into a nearby waterway? Does it enter the ocean?
2. On the other side of the paper, students will list some possible solutions to reducing nonpoint source pollution from their homes and community.

Conclusions

Nonpoint source pollution presents a significant challenge to address on a large scale, as it is pervasive and difficult to control. However there is much we can do to reduce nonpoint source pollution at its source, beginning at home, extending to our schools, and out in our community.

Extensions and applications

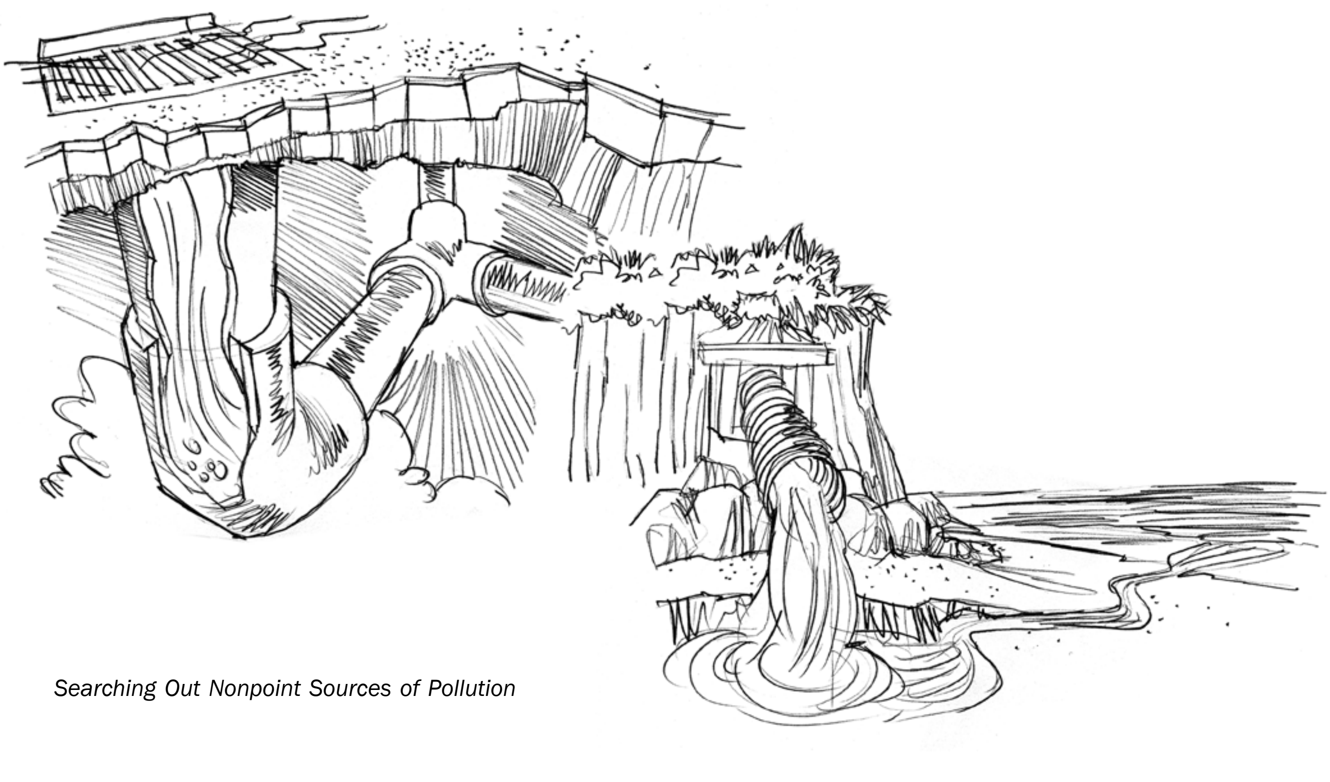
1. Using the maps and information from this activity, create a nonpoint source pollution display for your school and/or community.
2. Find out what types of pollutants your school is generating (detergents, pesticides, fertilizers) and make a list. Discuss with school staff nonpoint source pollution, and suggest alternative products.
3. Conduct a storm drain stenciling activity around your school to alert people about the hazards of nonpoint source pollution. For information and stencils, contact The Ocean Conservancy at *stormdrain@oceanconservancy.org* or (757) 496-0920. You may also contact your local public works department to find out if they have a stenciling program.
4. Write to local or state representatives to find out what measures are being taken (or considered) to reduce nonpoint source pollution in your community. (Refer to Appendix D, *Make Your Views Known*, for letter-writing tips.)

Adapted from

Save Our Seas, A Curriculum for Kindergarten through Twelfth grades. The Ocean Conservancy (formerly known as Center for Marine Conservation) and California Coastal Commission, 1993.

Nonpoint Source Pollutants

Pollutant types	Sources	Effects
Marine debris (e.g., plastics, glass, metals, woods)	Runoff from roads, landfills, and parking lots into storm drains; sewer systems, beach and boating activities	Can harm marine life by entanglement or ingestion
Sediments	Construction sites; agricultural lands; logging areas	Clouds water, decreases plant productivity; suffocates bottom-dwelling organisms
Excess nutrients (e.g., fertilizers, animal wastes, sewage, yard waste)	Livestock; gardens; lawns; sewage treatment systems; runoff from streets	Prompts phytoplankton or algal blooms; causes eutrophication (depleted oxygen), and odor
Acids, salts, heavy metals	Runoff from roads, landfills, and parking lots; salt from roadway snow dumping sites	Toxic to marine life and can be taken up by organisms and bioaccumulate in their tissues
Organic chemicals (e.g., pesticides, oil, detergents)	Forests and farmland; anti-fouling boat paints; homes (lawns); golf courses; sewage treatment systems; street runoff	Chronic and toxic effects on wildlife and humans, possibly carcinogenic
Pathogens (e.g., coliform bacteria)	Municipal and boat sewage; animal wastes; leaking septic/sewer systems	Causes typhoid, hepatitis, cholera, dysentery



Safe Substitutes: Reduce Nonpoint Source Pollution

At Home

Air Fresheners
- For sink disposal odors, grind up used lemons.
- For surface odors on utensils and chopping blocks, add a few drops of white vinegar to soapy water.

Deodorizers
- For carpets, mix 1 part borax with 2 parts cornmeal; spread liberally and vacuum after an hour.
- Sprinkle baking soda in the bottom of cat boxes and garbage cans.

Dish Detergents
- Use mild, biodegradable, vegetable oil-based soap or detergent.
- For dishwashers, choose a detergent with the lowest phosphate content.

Disinfectants
- For disinfecting tasks, use ½ cup borax in 1 gallon hot water.

Drain openers
- Pour boiling water down the drain once a week.
- For clogs, add a handful of baking soda and ½ cup white vinegar to your drain, cover tightly and let sit 15 minutes while carbon dioxide bubbles work on clog. Finish with 2 quarts boiling water, follow with a plunger.

Floor cleaners
- For plain wood floors, use a damp mop with mild vegetable oil soap and dry immediately.
- For painted or varnished wood floors, combine 1 teaspoon of washing soda with 1 gallon of hot water. Rinse and dry immediately.
- For vinyl floors, combine ¼ cup white vinegar and ¼ cup washing soda with 1 gallon of warm water, and mop.
- For scuff marks on linoleum, scrub with toothpaste.

Furniture polish
- For finished wood, clean with mild vegetable oil soap.
- For unvarnished wood, polish with almond, walnut, or olive oil; be sure to remove excess oil.
- Revitalize old furniture with linseed oil.

Glass cleaner
- Combine 1 quart water with ¼ cup white vinegar.

Laundry detergent
- Avoid products containing phosphates and fabric softeners.

Bathrooms
- Combine ½ cup borax in 1 gallon of water for cleaning and disinfecting toilets.
- Clean toilets frequently with baking soda.
- Tub and sink cleaners: Use baking soda or a non-chlorinating scouring powder.

For the Garden

Garden fertilizers
- Use organic materials such as compost, either from your own compost pile or purchased from the store.

Garden weed and fungus control
- Use less-toxic soap solutions for weed killers.
- For fungus, use less-toxic sulfur-based fungicides.
- To control powdery mildew on roses, spray both sides of rose leaves (in the morning, weekly) with a mixture of 2 tablespoons mild liquid soap, 2/3 teaspoon baking soda, and 1 gallon water.

Pest control
- For outdoor ants, place boric acid in problem areas.
- For indoor ants and roaches, caulk entry points. Apply boric acid dust in cracks and insect walkways. Be sure it's inaccessible to children and pets (it's a mild poison to mammals).
- For garden aphids and mites, mix 1 tablespoon of liquid soap and 1 cup of vegetable oil. Add 1 teaspoon of mixture to a cup of water and spray. (Oil may harm vegetable plants in the cabbage family.)
- For caterpillars in the garden, apply products containing *Bacillus thuringiensis* to the leaves when caterpillars are eating.
- For mosquitoes in the yard, burn citronella candles.

Source: *Take Me Shopping: A Consumers Guide to Safer Alternatives for Household Hazardous Products*. Published by the Santa Clara County Hazardous Waste Management Program.

Watch Out for These Toxic Ingredients!

Degreasers: trichloroethylene (TCE), toluene, methylene chloride. **Disinfectants**: o-phenylphenol, phenol chlorobenzene, diethylene glycol. **Drain cleaners:** sodium hydroxide, potassium hydroxide, hydrochloric acid. **Dry cleaning fluids:** TCE, perchloroethylene (PERC), 1,1,1-trichloroethane (TCA), naptha.. **Gasoline**: benzene, paradichlorobenzene. **Oven cleaner**: methylene chloride, xylene, toluene, methyl ethyl ketone chloride, nitrobenzene. **Spot remover or cleaning fluid**: carbon tetrachloride, 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), perchloroethylene (tetrachloroethylene, PERC). **Toilet bowl deodorizer**: paradichlorobenzene. **Upholstery cleaner**: TCE. Wood preservatives: pentachlorophenols (PCPs), arsenic.

Activity for All Grades

Science skills

- Identifying
- Classifying
- Hypothesizing
- Cataloging
- Graphing

Concepts

- Humans affect ocean ecosystems and marine wildlife.
- Through our efforts, we can make a difference in the amount of trash that enters the oceans.

Objectives

- Students will demonstrate the role they can play in marine conservation by participating in a shoreline cleanup.
- Students conduct the shoreline cleanup according to a scientific method.

Time to complete

Field trip to the beach, river, lake site: 2-3 hours at the site

Mode of instruction

Classroom discussion and preparation for field trip, then field trip to shoreline followed by data analysis in the classroom.

If you would like to do your cleanup on California Coastal Cleanup Day, it is held on the third Saturday in September. Begin planning as soon as school starts in the fall!

Activity CA3 Clean Shorelines, Clean Oceans: Shoreline Cleanup

Tons of marine debris are picked up each year off California's beaches, river banks, and lake shores. Be a part of the solution—do a shoreline cleanup with your class. You never know what you may find!

Background

If your students have completed the activities CA1: *Marine Debris—It's Everywhere!* and CA2: *Searching Out Nonpoint Sources of Pollution*, they will have an understanding of the many types of marine debris and its hazardous effects on wildlife. Now is the time to put this newfound awareness into action with a shoreline cleanup. The shoreline cleanup allows the students to participate in an immediate solution to the problem of marine debris; simultaneously, the students employ scientific methodology to analyze the problem of marine debris. They will form a hypothesis, decide on their purpose, follow a particular method, summarize their results, and make a final conclusion.

Picking up trash from beaches and waterways so it doesn't enter the oceans and harm marine life is clearly an important job. Why collect data on what you find? By collecting data, students can begin to understand the types and amount of trash littering the beach. From this information, students can also determine some possible sources of the debris. By determining what type of trash is littering the shore and how it might have arrived there, students will discover that marine debris is caused by human behavior. We all use and discard products that can become part of the problem, and by understanding this connection, we can begin to develop solutions to the problem. There are actions that we can take every day that can reduce marine debris.

Activity

Follow instructions under "Outline" (in the sidebar, p. 134) for preparation for field trip.

1. The day before the field trip, discuss these steps of scientific methodology with your students:
Purpose: Students will come up with a purpose for their scientific study. A likely purpose might be, "I want to understand where marine debris comes from."
Hypothesis: Have your students come up with hypotheses they can test by collecting data during the cleanup. Possible hypotheses might include: "There is more marine debris farther up the beach than closer to the water." Or, "There is more plastic debris than any other type of debris."
Method: Students will break into teams to comb two different sections of the beach. One team will clean near the water line, another will clean the upland portion of the shore. Within each team, students will break into groups of 3-4 students to cover a segment of their section. In each group, one student will be the recorder, one student will hold the trash

Materials

1. Separate bags for trash and recyclable debris
2. "Shoreline Cleanup Data Card" (There are two options available. *Option A* groups debris by its substance. This card allows for a reflection activity in which students determine what human actions led to the debris ending up on the shore, and allows them to understand which materials are most abundant. *Option B* is used by volunteers throughout the world during the International Coastal Cleanup. With this card, students organize the debris into source categories as they collect it.)
3. Clipboard and pencil for each small group (3-4 students)
4. School parental consent form
5. Adopt-a-Beach waiver form (if applicable)
6. First aid kit
7. Gloves (two for each small group)
8. Tide chart

and recycle bags, and two students with gloves will pick up the trash. Students will switch jobs half way through, so all students have an opportunity to pick up trash. Every item that is picked up is recorded on the data sheet. The groups will discuss and agree to which "category" each piece of debris belongs. If there is a question, the student should ask the teacher or adult supervisor (i.e., some debris will include both plastic and metal).

2. The morning of the cleanup, check weather conditions at the cleanup site and review the following safety information with the students:
   - Do not go near any large metal drums.
   - Do not pick up any sharp objects – inform an adult where the sharp object is located.
   - Notify an adult if you find a syringe.
   - Debris collectors wear gloves.
   - Stay out of dunes and any protected areas.
   - Watch out for wildlife and do not approach any animals you encounter.
   - Don't lift anything too heavy.
   - If you begin to feel very hot, dizzy or tired, drink some water and notify an adult.
   - If you are walking near the surf, never turn your back to the ocean.

3. At the site, select a stretch of shoreline that the teams will cover. Make sure you have adequate supervision of the teams if the stretch is a wide one (choose the stretch according to the age of your class, cover a wide stretch with older children, or a shorter one with younger).

4. Instruct students to keep their eyes open to possible clues as to debris sources, e.g. are there adequate trash cans, is there a nearby storm outfall, does the site get heavy use, do people fish in the area?

Preparation

Select a public site for the cleanup and a field trip date. For locations on the coast, San Francisco Bay, and some inland waterways, call (800) Coast-4U or visit www.coastforyou.org to find a local Adopt-A-Beach manager. (If you wish to hold your cleanup on Coastal Cleanup Day, the third Saturday in September, use the same phone number and webpage to obtain local participation information.) The beach manager will assist you in selecting a clean up location and will supply you with bags, gloves, and waivers for your students. Arrange with the beach manager to have the trash and recycling collected after your cleanup.

If you would like to do a shoreline cleanup and are in an inland area that is not covered by the Adopt-A-Beach program, try contacting your local city or county public works department for assistance with supplies or find a local citizens' group that holds cleanups in your area. (Check the on-line "Marine, Coastal & Watershed Resource Directory" at *www.coastforyou.org*.)

5. Have students assemble into their two teams (waterline and upper shore). Within their teams, have students break up into groups of four students:
   1. Data writer
   2. Debris bag holder
   3. Debris collector
   4. Debris collector
6. Within each group of four, distribute one trash bag, one recycling bag, two gloves (one for each of the two people who will pick up debris) and one data card with clipboard and pencil.
7. Define the boundaries of the project for the students and adult volunteers so no one strays away. Set a time for the completion of the cleanup and a meeting place, and identify a way of telling students when it is time to return (e.g., three blows on a whistle, a special classroom signal or call, etc.). Remind the students to only work in their designated area (water line or upper shore).
8. After the cleanup, pile the bags in two designated areas: one for recyclables, and one for nonrecyclables. Collect the clip boards and data cards. Have lunch and congratulate yourselves on a job well done. Be sure not to leave any trash from your lunches behind! You may place your trash in your bags.

Results and reflection

Back in the classroom, analyze the data collected at the cleanup:

1. Individually or in groups, provide students with copies of all the data cards. Have them tabulate the data card totals onto two new data cards—one for the water line and one for the upper shore. (This may be done as a homework assignment or it may be assigned to a designated two students if you prefer.)
2. Break the students into their small groups of four. Photocopy the two data cards that contain the totals from the beach cleanup and give each small group a copy of the card for the area that they cleaned up.
3. If Data Card Option A was used, the class (or each small group) will choose a method for organizing the data. Some ideas include keeping it organized by material (plastic, glass…), or organizing it by the source activity (fishing, littering, dumping...), or by the manner in which they think the debris reached the beach (from boats, from beach-goers, through storm drains…). You may choose to have students transfer their data to Data Card Option B to help guide them to possible conclusions as to the source of the debris.
4. Each small group will choose a method for displaying the data from their cleanup area: pie charts, line graphs, and/or bar graphs.
5. Have each team share their visual presentation of the data with the class. Did the results confirm the hypotheses that were made before the cleanup? Which was the most effective method of presenting the data? Which was most visually appealing? Which was the easiest to understand? Did they tell different stories?

Outline

Before class

Two weeks to one month before cleanup:

1. Select a cleanup site. The shoreline should be sand or gravel and known to collect litter.
2. Begin assembling the materials and support you need. (Decide whether to use Data Card *Option A* or *Option B*. Page 2 backside will be the same for either option.)
3. Arrange transportation to the site.
4. If using the Adopt-A-Beach Program, send the school's parental consent form and the Adopt-A-Beach waiver form home with the students to be signed and returned.
5. You may wish to obtain a SHARPS container for syringes the students may discover. Your local fire department can assist you.

Day before cleanup

1. Collect parental consent forms.
2. Break the class up into two teams. One team will be responsible for the upland portion of the shoreline (if there are dunes at the beach, this team will clean up the beach-side of the dunes). The other team will be responsible for the water line. Within each team, students will break out into small groups of four students.
3. As a group, predict the type of debris that each group will find. Will there be a difference? Why?
4. Discuss the purpose of the cleanup.
5. Go over the data cards with the students.
6. Remind the students to wear appropriate clothing for the cleanup: layers, closed-toed shoes, hats and sun screen. Suggest that they bring a bottle of drinking water for their own use during the field trip as well as a bag lunch. (You may want to encourage the students to try to create a "trash-free" lunch, using recyclable and reusable containers.)
7. Photocopy data cards (*Option A* or *Option B*), one per each group of four students.

Day of cleanup

Follow activity instructions.

Day after cleanup

Data analysis and classroom discussion.

6. After the presentations, conduct a whole class discussion that touches on relevant questions, such as:

- Where is the trash coming from?
- Do certain items indicate specific sources of debris? (For example, fishing nets represent the fishing industry and are an ocean-based source of marine debris.)
- How can the information that was collected be used by the students and others to reduce marine debris? (Perform Activity CA4 to delve further into this topic.)
- Why is it important to know the location of the debris and the date of the sampling? Where does most of the trash accumulate? Which items of debris do they think are the most dangerous to marine wildlife?
- How does it make them feel to see the trash along the beach?
- How does it make them feel to see the beach clean after their work?

Conclusions

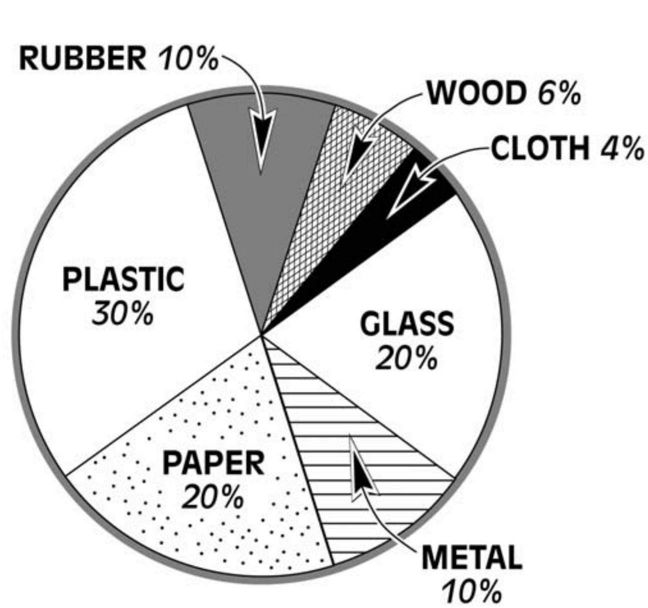
A cleanup helps us care for our shorelines and oceans, and tells us about what types of debris builds up on the shore. Knowing this, we can make some lifestyle choices to reduce marine debris.

Extensions and applications

1. Ask students to bring a "trashless" lunch to the cleanup, using reusable containers. Discuss alternatives to plastic sandwich bags, paper lunch sacks, disposable drink containers, etc.
2. Make a display of the trash collected.
3. Write an article about your beach cleanup for school or local newspaper (See Appendix D, *Make Your Views Known*).

Adapted from

Save Our Seas, A Curriculum for Kindergarten through Twelfth grades. The Ocean Conservancy (formerly known as Center for Marine Conservation) and California Coastal Commission, 1993.



Shoreline Cleanup Data Card

Option A, page 1

- ✔ Count items in groups of five and record the total. For example: ~~||||~~ ~~||||~~ || = 12
- ✔ Do not write the words "lots" or "many." Please count each item.
- ✔ Please leave natural items such as driftwood and seaweed on the beach.
- ✔ Avoid stepping on dune grass and plants. They hold the sand and prevent erosion.
- ✔ Work with a few people–have one person record the numbers while others collect and bag the trash.

PLASTIC

	# of items (~~||||~~ |||)	Total # of items
Bags:		
food bags/wrappers		
other bags		
Bottles:		
beverage bottles		
motor oil/lube bottles		
other plastic bottles		
Caps, lids		
Cigarette filters		
Cigarette lighters		
Cigar tips		
Cups, utensils, plates, straws		
Diapers		
Fast food containers		
Fishing line, nets, lures, floats		
Foam peanuts		
Six-pack holders		
Syringes		
Tampon applicators		
Toys		
Other plastic		

GLASS

Beverage bottles		
Other bottles/jars		
Other glass		

METAL

Bottle caps, pull tabs		
Beverage cans		
Other cans		
Nails		
Other metal		

RUBBER

Balloons		
Condoms		
Tires		
Other rubber		

PAPER

Bags		
Cardboard		
Cartons		
Cups/plates		
Newspapers/magazines		
Other paper		

WOOD

Lumber pieces		
Pallets		
Other wood		

CLOTH

Clothing		
Other cloth		

Adapted from The Ocean Conservancy's International Coastal Cleanup Data Card (in use 1986-2000)

ITEMS COLLECTED

The Ocean Conservancy
www.oceanconservancy.org

Human-made debris, trash and litter...

- Harms the environment & wildlife
- Causes communities to lose money
- Threatens human health & safety
- Looks bad!

Think about where all this debris comes from and how **we** can prevent it!

Please pick up all debris found on the beach. Record information on only the items listed below.

Keep a count of your items using tick marks and enter the item total in the box. **Example: [8] Beverage Cans** 卌 III

SHORELINE AND RECREATIONAL ACTIVITIES

(Debris from beach-goers, sports/games, festivals, litter from streets/storm drains, etc.)

- [ ] Bags____
- [ ] Balloons____
- [ ] Beverage Bottles (plastic) 2 liters or less____
- [ ] Beverage Bottles (glass)____
- [ ] Beverage Cans____
- [ ] Caps, Lids____
- [ ] Clothing, Shoes____
- [ ] Cups, Plates, Forks, Knives, Spoons____
- [ ] Food Wrappers/Containers____
- [ ] Pull Tabs____
- [ ] 6-Pack Holders____
- [ ] Shotgun Shells/Wadding____
- [ ] Straws, Stirrers____
- [ ] Toys____

OCEAN/WATERWAY ACTIVITIES

(Debris from recreational/commercial fishing and boat/vessel operations)

- [ ] Bait Containers/Packaging____
- [ ] Bleach/Cleaner Bottles____
- [ ] Buoys/Floats____
- [ ] Crab/Lobster/Fish Traps____
- [ ] Crates____
- [ ] Fishing Line____
- [ ] Fishing Lures/Light Sticks____
- [ ] Fishing Nets____
- [ ] Light Bulbs/Tubes____
- [ ] Oil/Lube Bottles____
- [ ] Pallets____
- [ ] Plastic Sheeting/Tarps____
- [ ] Rope____
- [ ] Strapping Bands____

SMOKING-RELATED ACTIVITIES

- [ ] Cigarettes/Cigarette Filters____
- [ ] Cigarette Lighters____
- [ ] Cigar Tips____
- [ ] Tobacco Packaging/Wrappers____

DUMPING ACTIVITIES

- [ ] Appliances (refrigerators, washers, etc.)____
- [ ] Batteries____
- [ ] Building Materials____
- [ ] Cars/Car Parts____
- [ ] 55-Gal. Drums____
- [ ] Tires____

MEDICAL/PERSONAL HYGIENE

- [ ] Condoms____
- [ ] Diapers____
- [ ] Syringes____
- [ ] Tampons/Tampon Applicators____

DEBRIS ITEMS OF LOCAL CONCERN

(Identify and count 3 other items found that concern you)

- [ ] ____
- [ ] ____
- [ ] ____

Page 2, Options A and B
Shoreline Cleanup Data Card

Beach Section (circle one): Water line Upper shore

Name(s)____

School____

Teacher____

Age____________________ Today's Date____________________

Shoreline cleaned ____

City/Location ____

Number of people working on this data card ______________________________

Number of trash bags filled_______________ Number of recycling bags filled_______________

SAFETY TIPS

1. Do not go near any large metal drums.
2. Do not pick up any sharp objects (inform your teacher where the sharp object is located.
3. Notify an adult if you find a syringe.
4. Wear gloves.
5. Stay out of dunes and any protected areas.
6. Watch out for wildlife and do not approach any animals you encounter.
7. Don't lift anything too heavy.
8. If you begin to feel very hot, dizzy or tired, drink some water and notify an adult.
9. If you are walking near the surf, never turn your back to the ocean.

What is the most peculiar item you collected?______________________________

Comments: ____

____

____

Activity for All Grades

Activity CA4
Preventing Pollution at the Source

From taking part in previous activities in this chapter, students now are familiar with how debris can pile up on the beaches. Now they will develop solutions to the problem of marine pollution.

Science skills
- Analyzing
- Problem solving

Concepts
- A specific problem definition will facilitate the development of effective solutions.
- Brainstorming is an effective approach to begin the problem solving process. It can be used to explore marine debris issues and solutions.

Objectives
- Students will be able to utilize a cooperative problem solving process designed to reduce marine debris.
- Students will implement their solution.

Time to complete
One hour

Mode of instruction
Students develop ideas to reduce marine pollution, analyze and evaluate the best ideas, and select the best one for actual implementation.

Materials
Overhead transparency of brain-storming tips

Preparation
Prepare overhead transparency.

Outline
Before class
Prepare overhead transparency.

During class
1. Divide students into small groups.
2. Assign or have students choose roles.
3. Display brainstorming tips overhead transparency. Students hold small group discussions. Each group reports on their solutions to the class.

Background
Students will learn how research and data collection can be used to develop solutions to environmental problems. Students will develop and try to implement solutions to the marine debris problem. No matter how young or old we are, we can all make a difference!

Activity
The Problem Solving Process
1. Hold a class discussion on the problem solving process (see page 140).

2. Tell students that they are now going to use the problem solving process to address the issue of marine debris. Write on the board the different steps and explain them:
   a. Understand and define the problem(s)
   b. Brainstorm solutions
   c. Analyze the solution suggestions
   d. Evaluate which solutions would be most effective and select the best solution.

3. Divide students into small groups (3-4 students). In the groups, assign roles or have students choose a role: recorder, discussion leader, spokesperson.

4. Display "Brainstorming Tips" on the overhead projector for students to refer to in their groups. Tell students they will now use the problem solving process discussed earlier to create solutions to problems associated with marine debris.

Results and reflection
1. Each group presents their problem definition and solution plan to the class. Ask for questions and comments. Ask that students note the ways their proposal could be improved.
2. The class selects the best plan by voting.
3. Elaborate on the best solution—describe it clearly. Would graphs, charts, or time lines help? Help the students design a graphic presentation of the classes' chosen solution. Then, have students create an action plan with timeline for implementation of their class solution.
4. Help students implement the action plan or send the recommendation to the appropriate city, county, or state agency. Consider the following for implementation: Which groups need to know about the proposal? Which groups will initially oppose it and how can their concerns be satisfied? What persuasive and educational techniques will be needed? Who will perform each task? Depending upon the age of your class, you may need to have suggestions ready for them to choose (e.g., local

Department of Public Works, EPA, California Coastal Commission, Harbormaster, etc.). Assist students in defining tasks and draw up a plan of action with names, tasks, and dates. Refer to Appendix D, *Make Your Views Known,* for ideas on effective letter writing techniques.

Conclusions

Humans are the source of marine debris, and we are also the solution. There are many ways we can work to reduce the marine debris polluting our oceans.

Extensions and applications

Invite someone from the school administration or community to class to help evaluate the class's proposed solutions.

Adapted from

Save Our Seas, A Curriculum for Kindergarten through Twelfth grades. The Ocean Conservancy (formerly known as Center for Marine Conservation) and California Coastal Commission, 1993.

WHAT IS THE GOVERNMENT DOING?

For centuries it was common practice for ships to dump their garbage at sea. The United Nations administers a treaty that provides a comprehensive approach to dealing with ocean dumping. The International Convention for the Prevention of Pollution from Ships is known as MARPOL 73/78 (MARine POLlution) and contains Annexes that deal with specific discharges: Annex I oil, Annex II hazardous liquids, Annex III packaged hazardous materials, Annex IV sewage, and Annex V garbage (including plastics). In order to implement MARPOL Annex V, the U.S. Congress passed the Marine Plastic Pollution Research and Control Act of 1987, which applies to both U.S. vessels and foreign vessels in U.S. waters.

Recently, it has become more and more evident that marine debris is also coming from land-based sources. Among these sources are combined sewer overflows. Usually found in older cities, these sewer systems are combined with stormwater drainage systems. When it rains, and too much water goes into the system, overflows of raw sewage and untreated pollutants from the streets are discharge *directly* into waterways. Discharges from land-based sources are subject to regulation under a federal law called the Clean Water Act. Land-based sources also include urban runoff from storm drains. It is a common misconception that the pollutants and debris washed down storm drains are removed at a treatment plant. In most cases, this runoff is discharged directly into local streams, rivers, and bays with no treatment whatsoever. The U.S. Environmental Protection Agency (EPA) requires cities with separate storm sewer systems to obtain a National Pollutant Discharge Elimination System (NPDES) permit. Cities must apply for this permit to ensure that their stormwater systems are operating as efficiently and cleanly as possible and that they are educating their citizens about the hazards of dumping debris and other substances down storm drains.

Other laws protecting coastal water quality include the federal Coastal Zone Management Act of 1972, the Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act), and the California Coastal Act of 1976, which guides the actions of the California Coastal Commission.

From: *Pocket Guide to Marine Debris*,
The Ocean Conservancy

Brainstorming Tips

1. Don't Criticize Others' Ideas
They will lose their train of thought and stop generating ideas.

2. More is Better
Write down as many ideas as you can. At this stage, don't worry about spelling, repetition, etc.

3. Connect Ideas When Possible
If something someone says sparks a thought, say your idea. Connect parts of your ideas with theirs when possible.

4. Be Free Wheeling and Don't Be Afraid to Express Crazy Ideas
A crazy idea now may seem plausible and original after more thought and research.

The Problem Solving Process

(Format for a class discussion)

Why is it important to understand and define the problem(s) before beginning to explore solutions? The more accurately and specifically a problem is defined, the easier it is to come up with effective solutions.

What are some examples of how different problem definitions might lead to different solutions? One problem definition might focus on the large numbers of cigarette butts found on beaches; another might focus on a lack of trash receptacles at a beach. If your students have participated in a shoreline cleanup, remind them about the data they gathered and analyzed during the cleanup, and the problems they identified. Is there anything else you observed at the shoreline that could help define the problems? If your students did not do a shoreline cleanup, discuss the problems they identified and learned about in CA1: *Marine Debris—It's Everywhere*, and CA2: *Searching Out Nonpoint Sources of Pollution.*

As a group, identify some examples of problem definitions for which the students will explore solutions. Discuss some possible solutions. The solutions could be as simple as initiating a letter writing campaign or as complex as working to get a law passed. For example, students in Massachusetts helped pass a law banning mass balloon releases.

Appendices

Appendix A.
Environmental Organizations and Programs

The following is a brief list of organizations that offer many environmental education programs related to the coast and ocean. They may provide tours, field trips, workshops, informational material, expert advice, and more. While they are organized by region, most provide resources of interest to educators throughout the state. Check out their website or call for information. For an up-to-date, more extensive list of organizations, along with detailed information about their programs, visit the California Coastal Commission's "Marine, Coastal & Watershed Resource Directory" at *www.coastforyou.org.*

Statewide

Algalita Marine Research Foundation
148 Marina Drive
Long Beach, CA 90803
(562) 598-4889
www.algalita.org

American Cetacean Society
P.O. Box 1391
San Pedro, CA 90733-1391
(310) 548-6279, *www.acsonline.org*

California Academy of Sciences
875 Howard Street
San Francisco, CA 94103
(Returns to Golden Gate Park in 2008)
(415) 321-8000
www.calacademy.org

California Coastal Commission
45 Fremont Street, Suite 2000
San Francisco, CA 94105-2219
(800) Coast-4U
www.coastforyou.org

California Department of Conservation
California Geological Survey
801 K Street, MS 12-30
Sacramento, CA 95814
(916) 445-1825
www.consrv.ca.gov/cgs

California Department of Fish and Game
1416 Ninth Street, 12th Floor
Sacramento, CA 95814-5511
(916) 653-6420
www.dfg.ca.gov

California Department of Water Resources
1416 Ninth Street
Sacramento, CA 95814
(916) 653-6192
www.dwr.water.ca.gov

California Integrated Waste Management Board
Office of Integrated Education
1001 I Street, MS #14A
P.O. Box 4025
Sacramento, CA 95812-4025
(916) 341-6769
www.ciwmb.ca.gov/schools

California Native Plant Society
2707 K Street, Suite 1
Sacramento, CA 95816
(916) 447-2677
www.cnps.org

California State Parks
1416 Ninth Street
Sacramento, CA 95814
(800) 777-0369
www.parks.ca.gov

California State Parks Foundation
800 College Avenue
P.O. Box 548
Kentfield, CA 94914
(415) 258-9975
www.calparks.org

California Regional Environmental Education Community (CREEC) Network
www.creec.org

Earthwater
P.O. Box 1850
Hayfork, CA 96041
(530) 628-5334
www.earthwater.org

Keep California Beautiful
4252 North River Way
Sacramento, CA 95864
(800) CLEANCA
www.keepcaliforniabeautiful.com

River of Words
2547 Eighth Street, 13B
Berkeley, CA 94710
(510) 548-7636
www.riverofwords.org

Surfrider Foundation
P.O. Box 6010
San Clemente, CA 92674-6010
(949) 492-8170
www.surfrider.org

The Marine Mammal Center
Marin Headlands
1065 Fort Cronkhite
Sausalito, CA 94965
(415) 289-7325
www.marinemammalcenter.org

The Ocean Conservancy
2029 K Street
Washington, DC 20006
(800) 519-1541
www.oceanconservancy.org

U.S. Geological Survey
Marine and Coastal Issues
345 Middlefield Road, MS 999
Menlo Park, CA 94025
(650) 329-5042
walrus.wr.usgs.gov

Water Education Foundation
717 K Street, Suite 317
Sacramento, CA 95814
(916) 444-6240
www.watereducation.org

North Coast Focus

Friends of the Dunes
P.O. Box 186
Arcata, CA 95518
(707) 444-1397
www.friendsofthedunes.org

Mattole Restoration Council
P.O. Box 160
Petrolia, CA 95558
(707) 629-3514
www.mattole.org

Northcoast Environmental Center
575 H Street
Arcata, CA 95521
(707) 822-6918
www.necandeconews.to

Stewards of the Coast and Redwoods
P.O. Box 2
Duncans Mills, CA 95430
(707) 869-9177
www.stewardsofthecoastandredwoods.org

San Francisco Bay Area Focus

Aquarium of the Bay
Embarcadero at Beach Street
San Francisco, CA 94133
(888) SEA-DIVE
www.aquariumofthebay.com

Bay Model Visitor Center
2100 Bridgeway
Sausalito, CA 94965
(415) 332-3871
www.spn.usace.army.mil/bmvc

City of Berkeley
Shorebird Park Nature Center
160 University Avenue
Berkeley, CA 94710
(510) 981-6720
www.ci.berkeley.ca.us/marina

Community Resources for Science
1375 Ada Street
Berkeley, CA 94702
(510) 527-5212
www.crscience.org

Cordell Bank National Marine Sanctuary
P.O. Box 159
Olema, CA 94950
(415) 663-0315
www.cordellbank.noaa.gov

Coyote Point Museum for Environmental Education
1651 Coyote Point Drive
San Mateo, CA 94401
(650) 342-7755
www.coyoteptmuseum.org

Crissy Field Center
603 Mason at Halleck
The Presidio
San Francisco, CA 94129
(415) 561-7690
www.crissyfield.org

Don Edwards San Francisco Bay National Wildlife Refuge
P.O. Box 524
Newark, CA 94560
(510) 792-0222
desfbay.fws.gov

East Bay Regional Park District
P.O. Box 5381
Oakland, CA 94605
(510) 562-PARK
www.ebparks.org

Environmental Education Council of Marin
42 Bolinas Road, Suite G
Fairfax, CA 94930
(415) 485-4908
www.eecom.net

Environmental Volunteers
3921 East Bayshore Road
Palo Alto, CA 94303
(650) 961-0545
www.evols.org

Farallones Marine Sanctuary Association
The Presidio
P.O. Box 29386
San Francisco, CA 94129
(415) 561-6625
www.farallones.org

Gulf of the Farallones National Marine Sanctuary
Fort Mason, Bldg. 201
San Francisco, CA 94123
(415) 561-6622
www.gfnms.nos.noaa.gov

Headlands Institute
GGNRA, Bldg. 1033
Sausalito, CA 94965
(415) 332-5771
www.yni.org/hi

Kids for the Bay
1771 Alcatraz Avenue
Berkeley, CA 94703
(510) 985-1602
www.kidsforthebay.org

Lawrence Hall of Science
Marine Activities Resources and Education (MARE)
1 Centennial Drive
Berkeley, CA 94720
(510) 642-5008
www.lawrencehallofscience.org/MARE

Literacy for Environmental Justice
800 Innes Avenue, Unit 11
San Francisco, CA 94124
(415) 282-6840
www.lejyouth.org

Marine Science Institute
500 Discovery Parkway
Redwood City, CA 94063
(650) 364-2760
www.sfbaymsi.org

Point Reyes Bird Observatory
3820 Cypress Drive #11
Petaluma, CA 94954
(707) 781-2555, *www.prbo.org*

San Francisco Bay National Estuarine Research Reserve
3152 Paradise Drive
Tiburon, CA 94920
(415) 338-3707
www.sfbaynerr.org

Save The Bay
350 Frank H. Ogawa Plaza #900
Oakland, CA 94612
(510) 452-9261
www.savesfbay.org

The Watershed Project
Richmond Field Station
1327 S. 46th Street #155
Richmond, CA 94804
(510) 665-3546
www.thewatershedproject.org

Tiburon Audubon Center
376 Greenwood Beach Road
Tiburon, CA 94920
(415) 388-2524
www.tiburonaudubon.org

Central Coast Focus

Camp SEA Lab
100 Campus Center, Bldg. 42
Seaside, CA 93955
(831) 582-3681
www.sealabmontereybay.org

Central Coast Salmon Enhancement
592 S. 13th Street
Grover Beach, CA 93433
(805) 473-8221
www.centralcoastsalmon.com

Coastal Watershed Council
P.O. Box 1459
Santa Cruz, CA 95061
(831) 464-9200
www.coastal-watershed.org

Dunes Center
1055 Guadalupe Street
Guadalupe, CA 93434
(805) 343-2455
www.dunescenter.org

Ecology Action
P.O. Box 1188
Santa Cruz, CA 95061
(831) 426-5925
www.ecoact.org

Elkhorn Slough National Estuarine Research Reserve
1700 Elkhorn Road
Watsonville, CA 95076
(831) 728-2822
www.elkhornslough.org

Environmental Center of San Luis Obispo
1204 Nipomo Street
San Luis Obispo, CA 93401
(805) 544-1777
www.ecoslo.org

Marine Advanced Technology Education (MATE) Center
Monterey Peninsula College
980 Fremont Street
Monterey, CA 93940
(831) 645-1393
www.marinetech.org

Monterey Bay Aquarium
886 Cannery Row
Monterey, CA 93940
(831) 648-4800
www.montereybayaquarium.org

Monterey Bay National Marine Sanctuary
299 Foam Street
Monterey, CA 93940
(831) 647-4201
www.mbnms.nos.noaa.gov

Morro Bay National Estuary Program
601 Embarcadero, Suite 11
Morro Bay, CA 93442
(805) 772-3834
www.mbnep.org

O'Neill Sea Odyssey
2222 East Cliff Drive, Suite 222
Santa Cruz, CA 95062
(831) 475-1561
www.oneillseaodyssey.org

Pacific Cetacean Group
P.O. Box 835
Moss Landing, CA 95039
www.pacificcetaceangroup.org

Save Our Shores
345 Lake Avenue, Suite A
Santa Cruz, CA 95062
(831) 462-5660
www.saveourshores.org

Seymour Marine Discovery Center at Long Marine Lab
100 Shaffer Road
Santa Cruz, CA 95060
(831) 459-3800
seymourcenter.ucsc.edu

Watershed Institute
CSU Monterey Bay
100 Campus Center
Seaside, CA 93955-8001
(831) 582-3689
watershed.csumb.edu

Southern California Focus

Agua Hedionda Lagoon Foundation
1580 Cannon Road
Carlsbad, CA 92008
(760) 804-1969
www.aguahedionda.org

Aquarium of the Pacific
100 Aquarium Way
Long Beach, CA 90802
(562) 590-3100
www.aquariumofpacific.org

Aquatic Adventures
2211 Pacific Beach Drive, Suite A
San Diego, CA 92109
(858) 488-3849
www.aquaticadventures.org

Bolsa Chica Conservancy
3842 Warner Avenue
Huntington Beach, CA 92469
(714) 846-1114
www.bolsachica.org

Cabrillo Marine Aquarium
3720 Stephen White Drive
San Pedro, CA 90731
(310) 548-7562, *www.cabrilloaq.org*

Catalina Island Conservancy
P.O. Box 2739
Avalon, CA 90704
(310) 510-2595
www.catalinaconservancy.org

Channel Islands National Marine Sanctuary
3600 S. Harbor Boulevard Ste.111
Oxnard, CA 93035
(805) 382-6149
www.cinms.nos.noaa.gov

Chula Vista Nature Center
1000 Gunpowder Point Drive
Chula Vista, CA 91910
(619) 409-5900
www.chulavistanaturecenter.org

Community Environmental Council
26 W. Anapamu Street, 2nd Floor
Santa Barbara, CA 93101
(805) 963-0583
www.communityenvironmentalcouncil.org

Crystal Cove State Park
8471 Pacific Coast Highway
Laguna Beach, CA 92651
(949) 494-3539 (Main)
(949) 497-7647 (Interpretive)
www.crystalcovestatepark.com

Earth Resource Foundation
P.O. Box 12364
Costa Mesa, CA 92627
(949) 645-5163
www.earthresource.org

El Dorado Nature Center
7750 East Spring Street
Long Beach, CA 90815
(562) 570-1745

Heal the Bay
1444 9th Street
Santa Monica, CA 90401
(800) HEAL-BAY
www.healthebay.org

I Love A Clean San Diego
4891 Pacific Highway, Suite 115
San Diego, CA 92110
(858) 291-0103
www.ilacsd.org

Malibu Foundation for Environmental Education
1471 S. Bedford Street # 3
Los Angeles, CA 90035
(310) 652-4324
www.malibufoundation.org

Natural History Museum of Los Angeles County
900 Exposition Boulevard
Los Angeles, CA 90007
(213) 763-3348, *www.nhm.org*

Newport Bay Naturalists and Friends
600 Shellmaker
Newport Beach, CA 92660
(949) 640-6746
www.newportbay.org

Ocean Institute
24200 Dana Point Harbor Drive
Dana Point, CA 92629
(949) 496-2274
www.ocean-institute.org

Orange County Coastkeeper
3151 Airway Avenue, Suite F-110
Costa Mesa, Ca 92626
(714) 850-1965
www.coastkeeper.org

San Diego Coastkeeper
2825 Dewey Road, Suite 200
San Diego CA 92106
(619) 758-7743
www.sdcoastkeeper.org

San Dieguito River Park
18372 Sycamore Creek Road
Escondido, CA 92025
(858) 674-2270
www.sdrp.org

Santa Monica BayKeeper
P. O. Box 10096
Marina del Rey, CA 90295
(310) 305-9645
www.smbaykeeper.org

University of Southern California Sea Grant Program
University Park, AMF 209
Los Angeles, CA 90089-0373
(213) 740-1961
www.usc.edu/org/seagrant

Appendix B.
Wetlands of California

Wetlands are one of California's most diverse habitats. They support a food web that includes large mammals and predatory birds, provide habitat for diverse terrestrial and aquatic plants and animals, protect shorelines from erosion, and control sediment and naturally treat toxic substances that wash down from streams and rivers. Wetlands are also valuable to humans for recreation, research, education, harvestable plants, and historical significance. This appendix contains a partial list of wetlands throughout California. Visit a wetland near you.

North Coast

Big River State Park
This park includes a 50 mile stretch of the river and its tributaries, and more than 1,500 acres of coastal wetlands. The 8.3-mile estuary is the longest undeveloped estuary in northern California.
www.mendocinolandtrust.org
www.parks.ca.gov, (707) 937-5804

Humboldt Bay National Wildlife Refuge
This refuge exists primarily to protect and enhance wetland habitats for migratory waterbirds using the Bay. In the winter, it is not unusual for over 100,000 birds to use the Bay as a feeding or resting site. Humboldt Bay Refuge is adjacent to Highway 101, near the cities of Arcata and Eureka.
www.fws.gov/humboldtbay

MacKerricher State Park
This park, near the town of Fort Bragg, encompasses nearly 2,300 acres, of which 454 offshore acres are designated as an underwater park. The MacKerricher Visitor Center contains interpretive displays on terrestrial and ocean ecology.
www.parks.ca.gov

San Francisco Bay Area

Bolinas Lagoon Preserve
Bolinas Lagoon Preserve contains 1,100 acres of tidal estuary supporting a rich biodiversity, with several rare, threatened and endangered species. It is located along the San Andreas Fault, 15 miles northwest of the Golden Gate Bridge on Highway 1.
www.bolinaslagoon.org

Don Edwards San Francisco Bay National Wildlife Refuge
The Refuge spans 30,000 acres of open bay, salt pond, salt marsh, mudflat, upland and vernal pool habitats located throughout south San Francisco Bay. A Visitor Center is near the east end of Dumbarton Bridge and the Environmental Education Center is on Zanker Road in Alviso.
www.fws.gov/desfbay

Palo Alto Baylands
This 1,940-acre preserve has a large resident population of birds, and is a major migratory stopover on the Pacific Flyway. The preserve, which includes an interpretive center, is north of Highway 101, and can be reached from the southeast from Shoreline at Mountain View Park.
www.cityofpaloalto.org/community-services/pk-baylands.html

Central Valley

Cache Creek Nature Preserve
This preserve is a 130-acre property in the lower Cache Creek corridor. Reservations are needed prior to visiting the preserve, which offers tours and activities for all ages. It is located west of Woodland, and north of Winters and Davis.
www.cachecreekconservancy.org

Cosumnes River Preserve
The Cosumnes floodplain is home to migratory waterfowl, greater sandhill cranes, rare reptiles and mammals such as the giant garter snake and the river otter. Teachers are required to attend a teacher workshop prior to scheduling a field trip to the Visitor Center. The preserve is about midway between Stockton and Sacramento.
www.cosumnes.org

San Luis National Wildlife Refuge Complex
This 26,609-acre refuge is a mixture of seasonal and permanent wetlands, riparian habitat, and native grasslands, alkali sinks, and vernal pools. The Refuge, located in the San Joaquin Valley, hosts interpretive wildlife observation programs.
www.fws.gov/sanluis

Vic Fazio Yolo Wildlife Area
This wildlife area contains 3,700 acres of restored wetlands and other associated habitats. It is home to the educational program, Discover the Flyway. The Wildlife Area is located on Interstate 80 at the Yolo Causeway between Davis and Sacramento.
www.yolobasin.org/wildlife.cfm

Central Coast

Elkhorn Slough National Estuarine Research Reserve
This 1,400-acre reserve hosts many programs that promote education, research and conservation of the slough. There is a visitor center and five miles of trails through oak woodlands, tidal creeks, and freshwater marshes.
www.elkhornslough.org

Morro Bay Estuary
Morro Bay, a small estuary of 2,300 acres, is fed by Chorro and Los Osos Creeks and is protected from the Pacific Ocean by a lengthy sand spit. The Estuary has a Visitor Center and a Volunteer Center.
www.mbnep.org

Pescadero Marsh Natural Preserve
This preserve is a popular spot for bird watchers and other naturalists. It is a refuge for blue heron, kites, deer, raccoons, foxes, and skunks. The Preserve is located 14.5 miles south of Half Moon Bay on Highway 1.
www.parks.ca.gov

Watsonville Sloughs
The Watsonville sloughs cover about 800 acres adjacent to the city of Watsonville. From Highway 1, most of the sloughs are hidden. Access points are not marked on most maps, which makes them difficult to find. Most are in private ownership, but a few roads cross the many fingers of the sloughs.
www.watsonvillewetlandswatch.org

Los Angeles and Orange Counties

Ballona Lagoon Marine Preserve
This 16.3-acre tidal wetland is a nursery and habitat for marine and mudflat creatures and a refuge for migrating birds. The lagoon is located in the City of Los Angeles on the Silver Strand Peninsula, adjacent to the Marina del Rey harbor.
www.blmp.org

Bolsa Chica Wetlands
The Bolsa Chica Ecological Reserve extends along the east side of Pacific Coast Highway in the city of Huntington Beach. The Interpretive Center is located at the southeast corner of Warner Avenue and Pacific Coast Highway. The Center organizes educational and volunteer programs.
www.amigosdebolsachica.org
www.bolsachica.org
www.bolsachicalandtrust.org

Upper Newport Bay
This estuary in Newport Beach is home to nearly 200 species of birds, as well as numerous species of mammals, fish, and native plants. A variety of educational programs are available.
www.newportbay.org
www.coastforyou.org

San Diego County

Agua Hedionda Lagoon
This 388-acre salt-water lagoon in Carlsbad allows recreational activities such as boating and fishing. A Discovery Center presents educational programs.
www.aguahedionda.org

Batiquitos Lagoon
This coastal wetland is 30 miles north of San Diego between the cities of Carlsbad and Encinitas. The Lagoon encompasses 610 acres with a visitor center and hiking trail along the north shore.
www.batiquitosfoundation.org

San Elijo Lagoon Ecological Preserve
This preserve encompasses nearly 1,000 acres of coastal strand, salt marsh, freshwater marsh, riparian scrub, coastal sage scrub, and mixed chaparral, with five miles of hiking trails and a Nature Center located in Encinitas.
www.sanelijo.org

Sweetwater Marsh National Wildlife Refuge
The 316-acre Sweetwater Marsh is located in San Diego Bay approximately seven miles south of downtown San Diego. The Chula Vista Nature Center provides interpretive and interactive exhibits.
www.chulavistanaturecenter.org

Tijuana River National Estuary Research Reserve
The reserve, which includes a visitor center, is located near Imperial Beach on the Mexican border. It encompasses 2,500 acres of beach, dune, mudflat, saltmarsh, riparian, coastal sage and upland habitats.
www.tijuanaestuary.com

Appendix C. Overfishing

There's a Limit to Fish in the Sea

Source: Monterey Bay Aquarium
www.montereybayaquarium.org

Ocean fish are wildlife—the last wild creatures that people hunt on a large scale. Once it seemed the ocean would supply an endless bounty of seafood. Today, we're discovering its limits. Between 1950 and 1994, ocean fishermen increased their catch 400% by doubling the number of boats and using more effective fishing gear. In 1989, the world's catch leveled off at just over 82 million metric tons of fish per year. That's all the ocean can produce. Sending more boats won't help us catch more fish.

Fisheries boom, then bust

Overfishing means catching fish faster than they can reproduce. Overfishing pushes the fish population lower and lower, until fish are so few that fishermen can't make a living any more. Many fisheries have already collapsed, throwing thousands of people out of work. All over the world, fishery after fishery booms as we send in more boats, then busts as the fish population crashes.

Off New England, cod were once so plentiful that boats had trouble pushing through them. Now the cod are nearly gone, and a centuries-old fishing tradition is ending. Other overfished species include Atlantic swordfish, Atlantic bluefin tuna and many kinds of West Coast rockfish. When one kind of fish is no longer plentiful, fishermen must move on to new species. Monkfish and sharks were once discarded as "trash fish," but now they're valuable—and are themselves overfished! Overfishing has also forced fishermen to look deeper for new species like orange roughy and Chilean seabass.

Chilean seabass live at least 40 years, orange roughy at least 100. A Pacific rockfish caught in 2001 was 205 years old—born when Washington was still president! Such slow-growing fishes are very vulnerable to overfishing.

Why are people still allowed to catch overfished species?

The laws that protect fisheries are made by state, federal and international authorities. These political bodies often cannot respond quickly to data from scientists and fisheries managers showing that a certain fish or fishery is in trouble.

On the "high seas," in international waters, fish may be caught by many different countries, each with different laws. Getting nations to agree on fisheries protections is a diplomatic process that can take years. Enforcing international fishing agreements is also difficult: often, there is little that can be done about fishing crews that choose to ignore laws and fish illegally in international waters. This is the case with the Chilean seabass fishery, where high levels of poaching or "pirate fishing" are undoing the benefits of a progressive international management treaty.

Within the U.S., new laws must go through a lengthy process before they're put "on the books" and start protecting fish. New restrictions on fishing are usually challenged by the fishing industry, which further delays protection of the resource. Lawmakers must also consider the short-term economic impact of restricting or closing a fishery—doing so is bound to cause upheaval to fishing communities, even if the goal is to protect the fishery in the long term. All of these factors mean that fisheries law—and its enforcement—often lags behind the best available science.

What can you do?

If you eat seafood, eat sustainable seafood! Sustainable means something that can continue long into the future. Sustainable seafood is fish or shellfish caught or farmed in ways that can be practiced now and for years to come, without jeopardizing the survival of any species or the integrity of the ecosystem. For a list of sustainable seafood choices and a list of seafood to avoid, visit the Monterey Bay Aquarium's website at *www.montereybayaquarium.org* and download their "Seafood Watch" seafood guide. You can also call the Seafood Watch Hotline at (831) 647-6873.

Appendix D.
Make Your Views Known

Contact Your Elected Representatives

Letters and phone calls from constituents can have a tremendous impact on the way city council members, county supervisors, mayors, and state and federal representatives vote on proposed legislation. Contrary to popular belief, your opinion does count. To ensure that your efforts are as effective as possible, try to follow these guidelines:

- Spell the representative's name correctly (e.g. Senator ___________).
- Keep the letter brief and succinct. Focus on one topic only.
- Refer to the bill in question by title, if possible, briefly noting its general purpose.
- Avoid a form letter response by asking a specific question or two. To ensure that you receive a reply, include a complete return address. If you are not satisfied with the reply, don't hesitate to write back.
- State your own views in your own words.
- Never threaten or appear over-emotional. A well-reasoned and thoughtful approach is more impressive and much more effective.
- Address your letters. Look in the phone book under the government pages for the phone number. Call and request the address, don't forget the zip code.
- If they act favorably on the issue, write back! Everyone appreciates a "thank-you" and it never hurts to remind your representative that you are paying attention to his or her record.

Express Your Views to Businesses and Government Agencies

If you think a private business or government agency should be doing more to protect our coast and ocean, or you'd like to thank an organization for a job well done, tell them so! Businesses and government agencies are generally very tuned in to public opinion. Your opinion can influence an organization's practices, decisions and long-term strategies.

- For businesses: Find a mailing address on the product or look up the company on the Internet. Look for a consumer contact or go straight to the top and address your letter to the president or CEO. For government agencies: find the mailing address on the Internet or in the phone book. Address your letter to the head of the agency.
- If you are a consumer of the company's product, say so.
- Explain in the letter how you have been sharing your opinion or plan to share it with others.
- Never threaten or appear over-emotional. A well-reasoned and thoughtful approach is more impressive and much more effective.
- Request a response (include a return address!) and politely express thanks for the reader's time.

Increase Your Impact with a Letter to the Editor

Studies show that letters to the editor are among the most widely read features of American newspapers. A letter to the editor is an excellent way to express your opinions about marine conservation, interest your neighbors in the issue, report your beach cleanup results, and perhaps interest your paper in covering the story.

To increase the chances that your letter gets printed, here are a few suggestions from experts:

- Use a typewriter or computer and double-space the lines. If you don't have a computer, print neatly.
- Plan your first sentence carefully. Try to refer to a previous article or letter that appeared in the same paper, if possible.
- Deal with only one topic in each letter, and present your ideas clearly and concisely.
- Use facts to support your argument—you are educating as well as advocating—and don't use sarcasm or hostile language.
- Appeal to readers' sense of fair play and justice. Challenge them to respond.
- Try to be practical and hopeful. People respond when they believe your cause has a chance of succeeding.
- Always supply your name and address. Editors are unlikely to print letters that are not identified.