Watershed Academy Activity Guide

TABLE OF CONTENTS

CREDITS

Original Production Team, Contributors, and Reviewers

Developers: Michelle Templeton, Cristy Cassel, Julia Davenport

Contributors: Stacia Fletcher, Michele Roest, Sonya Padrón

Reviewers: Dawn Hayes, Liz Love, Seaberry Nachbar, (Need to list SEP members)

Layout: Renee Krueger

Funding: The Monterey Bay Sanctuary Foundation and the Monterey Bay National Marine Sanctuary are grateful to the California Impact Assistance Program and the Bay Watershed Education and Training Program (BWET) for funding this important project.

Acknowledgements
This edition of the Watershed Academy Afterschool Program Activity Guide is the product of a multi-year effort by dedicated individuals and organizations. The original document was developed and field-tested in 2002 in partnership with the P·jaro Valley Unified School District through P·jaro Middle School. Special recognition to Melody Randel who worked with the Monterey Bay National Marine Sanctuary's MERITO program to pilot the Activity Guide with her afterschool program students and to Kenton Parker who facilitated the program's field component. Special thanks also go out to all of the people who collaborated in the development of the watershed science conservation kit, which accompanies the guide.

We sincerely hope this guide and the kit will contribute to development of knowledgeable young people who value the protection of our watersheds and oceans. After all, the youth of today are the decision makers of tomorrow.

Dear Watershed Educator:

The "Watershed Academy" Activity Guide was developed and field-tested in 2002 in partnership with the Pájaro Valley Unified School District through Pájaro Middle School. This bilingual (Spanish-language) activity guide was designed for the middle school level to enhance students' understanding of marine science, math and reading, with a special emphasis on English Language Development (ELD). With such success in its first years of implementation, we are thrilled to be able to provide this program to you and your students.

This project is part of the Monterey Bay National Marine Sanctuary's MERITO (Multicultural Education for Resource Issues Threatening Oceans) program, a marine conservation outreach effort comprising approximately twenty-five regional groups that participate in ocean and watershed education programs serving Hispanic/Latino students, teachers, adults and families.

This guide is one component of the marine science conservation kit you will receive prior to launching your program. The goal of this guide, the marine conservation kit and the watershed training component is to contribute to the protection of our watersheds and oceans through education on marine conservation issues. The guide features classroom and field activities focused on resource management issues such as water quality, restoration science, and environmental stewardship that are aligned to district and state science, math, language arts, visual and performing arts and English language development standards.

Program learning objectives include:

- Developing an awareness of the Monterey Bay National Marine Sanctuary and other natural resource management areas such as National Estuarine Research Reserves and California State Parks
- Understanding the connection between our land-based actions and the health of our oceans
- Gaining a better understanding of science related careers and the academic steps needed to get there
- Building academic confidence and tools to succeed in higher education
- Being introduced to environmental education concepts and sharing those concepts with families and communities, with the long-term goal of protecting our watersheds and sanctuaries into the future

Highlights of the program include:

- A field-tested marine science guide including bilingual classroom and field activities which addresses district and state standards, including ELD
- Field trip activities at natural resource management areas and other environmental study sites
- Native plant restoration and water quality monitoring student projects
- A "Family Watershed Night" where students present projects to parents

Thank you for participating in this valuable program. For more information on MERITO, please visit the MERITO website at: http://montereybay.noaa.gov/educate/merito/welcome.html. We welcome any comments!

Best Regards,

Dawn L. Hayes
Education & Outreach Coordinator

MERITO Watershed Academy

Afterschool Program

Making Meaningful Connections with Nature

Building Stewardship

The Monterey Bay National Marine Sanctuary's Multicultural Education for Resource Issues Threatening Oceans (MERITO) program was developed to engage our local communities in ocean protection. MERITO's Watershed Academy Afterschool Program is designed to provide students with memorable and meaningful experiences in nature. As an educator/youth leader, you play a vital role in building strong, fair and conscientious future community members and potential world leaders. This program aims to give you the tools and local support to facilitate a greater understanding of ocean-related issues among your students, ultimately allowing future community members to actively contribute to protection of our special watershed and marine resources. This guide provides service learning projects, classroom/group lessons and inspirational games.

Planning Your Year

While MERITO staff will provide guidance in developing your program calendar, you have the freedom to choose lessons that compliment your interests, expertise or curiosity. Developing your program calendar will be one of the first and most important things you do in the Watershed Academy. Science experts have partnered with this program to provide a wealth of knowledge and opportunity to your students. In order to provide a quality experience for you and your students, experts must be contacted with advanced notice. Most requests will require a minimum of 2 weeks to prepare for your program visit. MERITO staff are always available to help facilitate your program planning or communications with guest presenters.

Peer-to-Peer Learning

Anytime you have the opportunity to have students teach one another, it enhances their experience. Peer to peer sharing is particularly valuable with English language learners. Using students to help translate or interpret information and concepts to one another reinforces topics for everyone while fostering a sense of responsibility. This teaching style also develops an acceptance of others and builds confidence in communication skills.

Journaling

Journaling should be an exciting balance of creativity, communicating ideas and recording science. With each activity in this guide you will find various journaling components. Journal prompts have been developed to help students reflect on their experiences and tie their experiences to the bigger picture.

Take Home Message

Students should always be able to identify a key conservation concept that is clear enough in their minds that they can share it with their families or in their communities. Having a clear understanding of the conservation goal prior to leading your class through an activity may be the most important thing you can do.

Know Your Background and Make it Relevant

We all come from diverse backgrounds with varied experiences, values and knowledge. Be aware of your background and how it might influence the way you communicate certain concepts to students. Some students can pull away if they can't relate to the concept they are studying. Always make it relevant!

Solutions for the Future

Try to provide students with options and possible solutions, even when addressing serious conservation issues. Building bridges, not walls, requires working together to create solutions, rather than to place blame. Be honest with your students and let them seek the answers to some of the challenges we face. Most of all have a blast in your watershed to keep students coming back for more!

The Monterey Bay National Marine Sanctuary

National Marine Sanctuaries are our nation's underwater "crown jewels," much like our treasured National Parks. Today we have a system (much like the National Park System) of 13 National Marine Sanctuaries. In 1992, Monterey Bay and surrounding coastal areas were designated the Monterey Bay National Marine Sanctuary. National Marine Sanctuaries are a tool used by the U.S. government to provide comprehensive, long-lasting protection to selected areas of the marine environment. An area is designated as a National Marine Sanctuary because it contains unique natural and cultural features of national significance, including spectacular wildlife, diverse and highly productive habitats, threatened and endangered species, and historic artifacts.

Sanctuaries harbor a dazzling array of algae, plants, and animals. These protected waters provide an important habitat for species close to extinction and they protect historically significant shipwrecks and archaeological sites. They serve as natural classrooms for students of all ages and as living laboratories for scientists. Sanctuaries are cherished recreational spots for diving, boating and sport-fishing. They also support valuable commercial industries such as marine transportation, fishing, and kelp harvesting. The perpetual challenge of managing these areas is to maintain the critical balance between environmental protection and economic growth.

The Monterey Bay National Marine Sanctuary is a big place. Stretching from Marin to Cambria, the Monterey Bay National Marine Sanctuary includes 276 miles of shoreline and 5,322 square miles of ocean. The area covered by the Sanctuary equals the area covered by the entire state of Connecticut. The Sanctuary extends from the high tide line on land to an average 30 miles offshore. The Monterey Bay National Marine Sanctuary is one of the largest marine protected areas in the world!

Sanctuary Habitats

LESSON 1.1

Summary

In this activity, students are introduced to seven habitats in the Monterey Bay National Marine Sanctuary. Students will learn which animals call these habitats home, and how the habitats are connected to watersheds. Students create a mural depicting Sanctuary habitats and identify and place species in their habitats.

Learning Objectives

Students will be able to:

- Explain the words habitat and species in their own words
- Identify at least four of the habitats in the Sanctuary and describe their characteristics
- List at least four inhabitants of the Sanctuary and the habitat in which they live

Background

The Monterey Bay National Marine Sanctuary was established to protect the diverse underwater habitats (homes for living things) and inhabitants (the living things in their habitats) found along the central coast. Many habitats are found in the Sanctuary: rocky shores, sandy beaches, sandy seafloors, kelp forests, wetlands, underwater canyons, open oceans and deep seas. These different and varied habitats provide homes to numerous living things. The MBNMS has a duty to protect the thousands of plants and animals living in Sanctuary habitats.

Sanctuary Habitats

Watersheds

Over 6,000 square miles of land drain into the Sanctuary. Water moves over the land and drains into streams, creeks, and rivers. These waterways and the land draining into them are called watersheds. There are eleven major watersheds draining into the Monterey Bay National Marine Sanctuary.

As water moves over the land, it picks up things in its path. Some natural things, like twigs and pebbles, make their way downstream. Other non-natural, human-produced items, like trash and chemicals, follow the same route.

The Rocky Shore

Rocky shores are found where the sea meets a rocky part of the coastline. Crashing waves and changing tides characterize the rocky shores. The position of the moon and the sun relative to one another and to the earth influence tides (the rise and fall of sea level). Along the California coastline there are two high tides and two low tides each day. The area of land between the highest high tide and the lowest low tide is called the intertidal.

Duration

Define habitats and species: 20-40 minutes
Habitat and species drawing: 60 minutes
Short on time option: 20 minutes
Closing activity: 10-15 minutes

Teacher Prep

1. Read activity background
2. Photocopy Habitat Mural Templates
3. For Option 1 Mural: two-foot wide butcher paper, cut into 8 squares, 2' x 2' each. Students will pencil in grids, or to save time, lightly pencil in a grid on each square before handing out to students (four vertical and horizontal lines; each square measures six inches).

Sanctuary Habitats

LESSON 1.1

Materials

- Sanctuary poster (provided in kit)
- Colored sticky dot

Option 1:

- paper for mural (see teacher prep)
- Colored marking pens, paint, paint brushes, crayons, colored pencils
- Scotch tape
- Set of species cards (provided in kit)
- 8 squares of butcher paper cut 2 feet by 2 feet each
- Habitat mural templates

Vocabulary

Biodiversity
Deep Sea
Elkhorn Slough
Habitat
Kelp Forest
Monterey Bay National Marine Sanctuary
Monterey Canyon
Open Ocean
Rocky Shore
Sandy Beach
Sandy Seafloor
Species
Watershed
Wetland

Crashing waves make life very challenging along the rocky shore. Some organisms use special body parts to hold on tight. Mussels, for example, anchor themselves to rocks using strong, durable threads. Sea stars and sea urchins use hundreds of tiny feet tipped with suction cups to grab onto rocks. Other animals are shaped to withstand strong waves. Limpets, a relative of snails, have flat shells so waves move smoothly over their bodies. Other organisms take cover from waves by hiding under other animals, seaweeds, or rocks.

Insert Diagrams 1.1 A,B,C,D: Line art of mussel (with threads), sea star and sea urchin (showing tube feet), crabs hiding in crevices and brittle stars hiding under rocks).

Many organisms living along the rocky shores are covered by seawater and then exposed to air twice each day. Invertebrates, animals without backbones, are abundant in the intertidal. Most invertebrates breathe using gills and must keep their gills moist to breathe. Mussels and many snails close their shells tightly when the tide goes out to retain moisture while hermit crabs may hide under damp seaweed.

Organisms must also compete for space, find a meal, and avoid being eaten. If you look closely at intertidal organisms, you can find body structures that help them to do these things to survive!

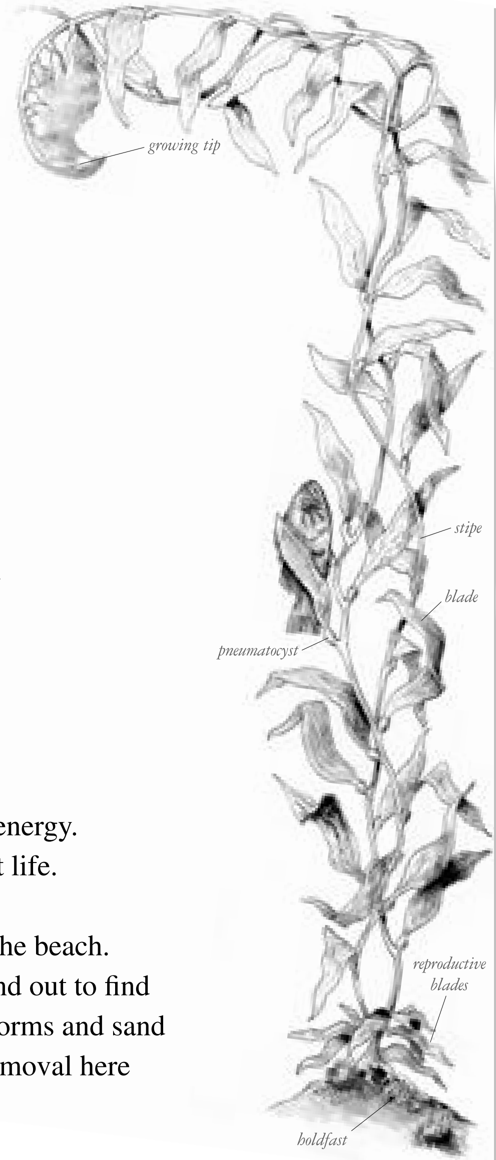
The Kelp Forest

Underneath the surface of the ocean, the shore extends to the area of the ocean always covered by water, the subtidal. Kelp, a brown alga, grows just offshore in cold waters with rocky bottoms. Giant kelp uses a root-like structure called a holdfast, to hold tightly to rocks up to 27 meters (90 ft) deep. Without a rock for attachment, kelp cannot grow. Kelp stretches upward, forming a cover, or a canopy, in sunny surface waters. Little air sacs, called floats or pneumatocysts, along the body of the kelp help keep it afloat. Long, leaf-like blades absorb nutrients from the ocean water and energy from the sun.

Sanctuary Habitats

LESSON 1.1

GIANT KELP *Macrocystis pyrifera*



Kelp forests are among the most biologically rich (productive) habitats in the world.

Giant kelp grows four or five inches a day, and when environmental conditions are perfect, it can grow ten to eleven inches a day.

Kelp forests provide homes for many different animals like brittle stars and worms that live in the nooks and crannies provided by the holdfast. Kelp rockfish like to hang suspended near the blades of kelp, kelp surfperch and sea otters, prefer to live in the top layer of kelp, the canopy, which spreads out along the surface of the water.

The Sandy Beach
Sandy beaches are diverse, ever-changing places. From pounding waves to heavy winds, beaches are constantly being redefined by seasonal changes in energy. Beaches support a great variety of animal and plant life.

The swash zone is the wet, wave-splashed area of the beach. Small birds called sandpipers chase the waves in and out to find food buried in the sand. Polychaete (segmented) worms and sand crabs also thrive in this zone. Sand, or sediment, removal here is high due to wave action.

The lower beach or low intertidal zone is only exposed at the lowest tides and is mainly a submerged habitat. Clams, moon snails, and surf perch live here during high tide. Most animals living here burrow down under the sand or hide on top of the sand using camouflage. Sand dabs, or flatfishes, use camouflage and change the colors of their bodies to match the surrounding sand and move offshore when tides are lowest.

The Sandy Seafloor
Close to shore but below the intertidal zone, wave action makes the sandy seafloor a rough and tumble environment to live in. Many animals, like clams and sand crabs, escape the wave action by burrowing underneath the sand.

Journal Prompt Closing Activity

After placing the mural on the wall have groups meet and take five minutes to decide their favorite habitat. Groups take turns sharing with the class what makes their chosen habitat and the species that live there special.

Activity Extensions

Place all of the habitat sheets and their species on the floor or taped on the wall as a mural. Have the class choose one habitat, or section, to explore further. Pick up the species cards from this habitat, and, one by one, ask which group placed the species card in that habitat and why. Does anyone think this species doesn't belong here? Are there other habitats where this species can be found?

Seaweeds do not usually grow on the sandy seafloor. Animals living here must rely on other sources of food. Many sandy seafloor animals eat detritus, particles of dead plants and animals. Other animals like clams, filter tiny plants and animals called plankton from the water. Some animals, like sea cucumbers, ingest sand to get detritus from it.

Animals living burrowed beneath the sand must find ways to get food and to obtain oxygen while buried. Burrowing animals include worms, clams and crabs.

The Open Ocean

The open ocean is far offshore. There are no crashing waves or changing tides in the open ocean but challenges are present in this wide-open world without boundaries or places to hide. Some animals, like jellies, try to escape detection by being transparent. Counter-shaded animals like sharks, are darker on their backs and lighter on their bellies. Countershading helps animals to avoid being seen by predator or prey from both above and below.

Plants and animals living in the open ocean are often grouped into two categories, swimmers (called nekton) and drifters (called plankton). The strong-swimming whales, tunas, and sharks and less-powerful animals still able to swim against a current, like turtles, are all members of the nekton. Those organisms unable to swim against a current are called plankton. Most plankton are very tiny plants and animals at the mercy of the currents. However, larger animals unable to swim against currents are also members of the plankton, like jellies and ocean sunfish.

The Deep Sea

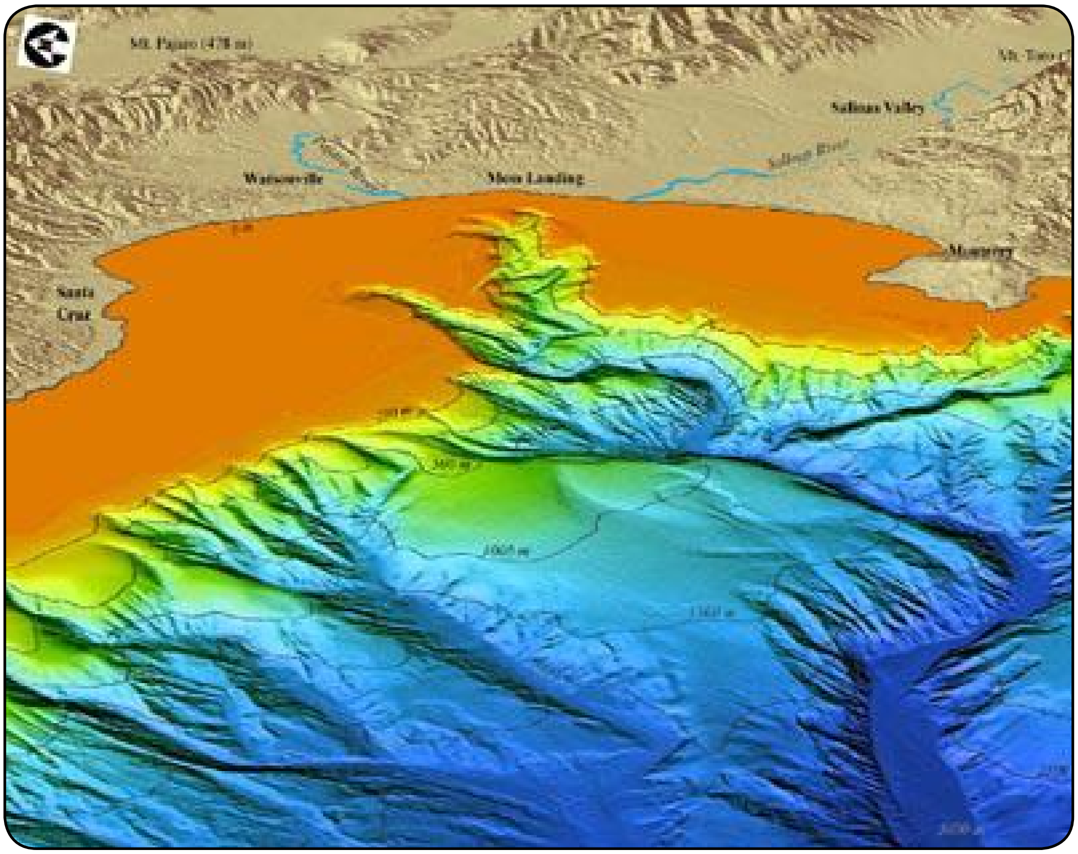
Waters deeper than 200 meters (656 feet) make up the deep sea habitat. Oceans cover over 70% of the earth and the deep sea habitat is the single largest habitat on the planet.

In the deep sea it is dark and very cold. Very little sunlight reaches depths between 200 and 1,000 meters. Below 1,000 meters (3281 feet) the deep sea exists in complete darkness. Many animals living here use bioluminescence (the biological production of light) to scare predators or attract mates or food. Food is scarce because there is not a lot of sunlight and plants are unable to grow. Animals like the gulper eel, the viperfish, and the deep-sea anglerfish have huge mouths they use to capture a meal, whenever one might swim by.

The average temperature in the deep sea is near 4° Celsius (39.2° Fahrenheit). Imagine swimming in a pool filled with ice water.

There is a tremendous pressure in the deep sea. Water is very heavy. As the depths of the ocean increase, the column of water above increases and so does the weight pressing down.

Monterey Canyon



Within the Monterey Bay National Marine Sanctuary is a unique deep sea environment very close to shore. A vast underwater canyon begins a steep drop off just off the coast of Moss Landing in between Santa Cruz and Monterey. This canyon, beginning in Monterey Bay, is called the Monterey Canyon. The Monterey Canyon reaches a depth of 3,656 meters (almost 2 miles) just 96,561 meters (60 miles) offshore. This canyon is as deep as the Grand Canyon in Arizona and is two miles under the sea.

Wetlands

Wetlands are areas of land with high soil moisture. A wetland can be covered by salty or fresh water. Unlike rivers, wetlands are usually less than six feet deep.

Sloughs (pronounced "slews") and estuaries are examples of wetlands. Sloughs and estuaries are calm, winding waterways with mud or grasses along the edges. Elkhorn Slough, located near Moss Landing in central California, is part of the Monterey Bay National Marine Sanctuary. This slough is an extension of the Pacific Ocean and the main channel reaches inland over seven miles. A slough can be connected directly to the sea or be completely detached. Elkhorn Slough is connected to the sea and salty water is found in the Slough.

Estuaries, unlike sloughs, are fed with fresh water on one end and salt water from the sea on the other. Elkhorn Slough is a seasonal estuary. When it rains in the winter, freshwater runoff from land drains into the slough and meets saltwater entering from the sea.

Both sloughs and estuaries provide protected and calm places for animals to find food and to reproduce. The waters within these habitats are protected from wave action and are often murky. Because slough and estuary waters are calm and "cloudy," animal babies are often safer here than they would be if they were born at sea. In the spring, leopard sharks, bat rays, flatfish, and many other animals come into Elkhorn Slough to give birth.

As the tide goes out, the slough's muddy bottom is exposed and little holes dot the surface. Animals like fat innkeeper worms, clams, and worms create these holes as a connection to the surface of the mud. When the tide comes in, these holes allow burrowing animals to get food and oxygen from the water.

Activity Procedure

Defining Habitats and Species

1. Ask students: Where is the Monterey Bay National Marine Sanctuary? Where does it begin? Where does it end? How do we know when we are in the Sanctuary? Is there a gate? The Sanctuary extends from the shoreline out to about 30 miles, and stretches 276 miles from Marin to Cambria. Whenever you are in the ocean or standing on the beaches in San Mateo, Santa Cruz, Monterey, and San Luis Obispo Counties, you are in the Monterey Bay National Marine Sanctuary.
2. Do we live in the Sanctuary? We live in watersheds that feed into the Sanctuary waters; we live on the edge of the Sanctuary, and all of our rivers and streams empty into the Sanctuary and connect us to it.
3. Choose one student to place a sticky dot where your school is on the Monterey Bay National Marine Sanctuary poster.
4. Ask students: Can you think of some examples of habitats? What makes a habitat? A habitat can be a forest, stream, desert, ocean, lake. A habitat is where living things get all of the nutrients, water, shelter, and space that they need to survive. Where is their habitat? The students' homes or apartments.
5. Ask students: What are some habitats you visit? Who lives in those habitats? Schoolyard habitat—birds, bugs, mice; their own backyards—birds, bugs, wandering cats; a wetland habitat they walk through on their way on their way to the store—birds, foxes, water insects, and plants.

6. Tell students: There are seven main habitats in and around the Sanctuary. Hold up each mural section worksheet one by one and read out loud its description. After reading each description, ask students: Who lives in these habitats? Fish in kelp forests, crabs in wetlands, birds in sandy beaches, whales in the open ocean.
7. Tell students: Species are different kinds of living things. What are some examples of species? Cat, dog, horse, fish, human, bunny. What makes something a species? A species is a kind of animal or plant. A species—always use the 's' even when speaking of one animal—is capable of breeding with others like it [= interbreeding]. For example, dogs are one species, cats are another. In some cases, different yet close species can interbreed, such as a donkey and a horse, but that pairing creates a mule (= hybrid) which is unable to breed. Tell students: 'Species' is a word we use to describe how living things are grouped. The scientific name of species' tells us whether or not they are related. For example, dogs and wolves are related but not the same species.
8. Ask students: Have you heard of the word biodiversity? Biodiversity is the variety of life on earth, all the species in the world, from the tiniest microbes to the tallest trees. All of earth's ecosystems and the living things within them that have evolved over time are part of our planet's biodiversity. What are some examples of biodiversity? Think of a group of organisms that has a lot of diversity in it—such as butterflies or birds—with many different sizes and shapes of species even though they are in the same group.
9. Wrapping it up. Tell students: Each species depends on its habitat for survival, and each species plays an important role in the functioning of the habitat. Now they'll have a chance to get creative and design a mural with the habitats in the Sanctuary, and find out who lives in them.

Placing Species in their Habitats

Two options are available. In Option 1 students create a mural (use if you have the time and the wall space to hang squares of large butcher paper) then place or draw species. In Option 2 students use the worksheets as the mural (use if you have 20 minutes or so) then place or draw species.

Option 1: Drawing the mural

1. Using two-foot-wide butcher paper, cut into 8 squares, 2 feet by 2 feet each. Students will pencil in grids, or, to save time, draw the grids beforehand (four vertical and horizontal lines; each square measures six inches).
2. Break students into eight equal groups. Distribute one mural section worksheet to each group. Tell students they will have 30 minutes to draw their mural section.

3. Students take their worksheets with them to the mural station (on the wall or at desks). On the poster paper, they lightly pencil in a grid of four equally spaced horizontal and vertical lines (matching the scale on the mural section worksheet). Teacher tip: to save time, make grid in advance as described in “Teacher Prep” below.
4. In their groups, students take turns drawing and reading out loud the habitat description on their worksheet. Make sure they only draw what is on their sample mural section worksheet at this point.

Drawing the Species

1. After the mural sections have been drawn, tell students they will now either draw or place species in their habitats. They will have five minutes at each habitat (if you have more time, let them spend ten minutes at each habitat). Teacher Tip: The species cards are used in many later activities, so it is best if students draw their species in their habitats. Allow extra time for this, or keep the cards up there for now and have the students draw them another day.
2. Divide species cards into eight equal, random batches and give each group a batch. Each group starts off at a different station.
3. In each group, students take turns reading aloud the information on the back of the species cards and the group decides which of their species they want to draw or place on the mural. Using the image and reading the information on the back of the species cards, students either draw the organism (preferred) or tape the card in the habitat where it belongs. Have students neatly write the name of their species underneath it—common name only.
4. Have each group take their mural section up to the front of the room and assemble the mural.

Option 2: Short on time? Worksheets as Mural

1. Break students into eight groups.
2. Place one mural section worksheet at each station.
3. Divide species cards into eight equal, random batches and give each group a batch. Each group starts off at a different station.
4. In each group, students take turns reading aloud the information on the back of the species cards and the group decides which of their species belong in the habitats at that station. Place the species cards on the correct habitat.
5. After ten minutes, switch stations, leaving the cards that match, but taking with them the cards that were not placed yet. Rotate through all stations.
6. You can use the habitat worksheets themselves to make a smaller mural on the wall. This mural will be 32” x 22” and will be harder to work with if you want to tape the species cards onto it. To make room for placing the species that live in the habitats, leave space around each worksheet to tape the overflow cards.

Habitat Mural Template

Crashing waves, changing tides, and sandy shores define the sandy beach.

The Sandy Beach

Sandy beaches are diverse, ever-changing places. From wave splashed shorelines to rolling dunes, beaches support a great variety of animal and plant life.

Beaches are divided into zones based on the amount of time the area is exposed to air. The upper intertidal zone is where you will find the “driest” beach habitat. This is the area of the beach just below the dunes. Snowy plovers make nests in this area.

The next zone, the mid-littoral zone is occasionally exposed to high tides. Beach wrack, or piles of dead seaweeds, are found here and provide food and hiding places for other animals.

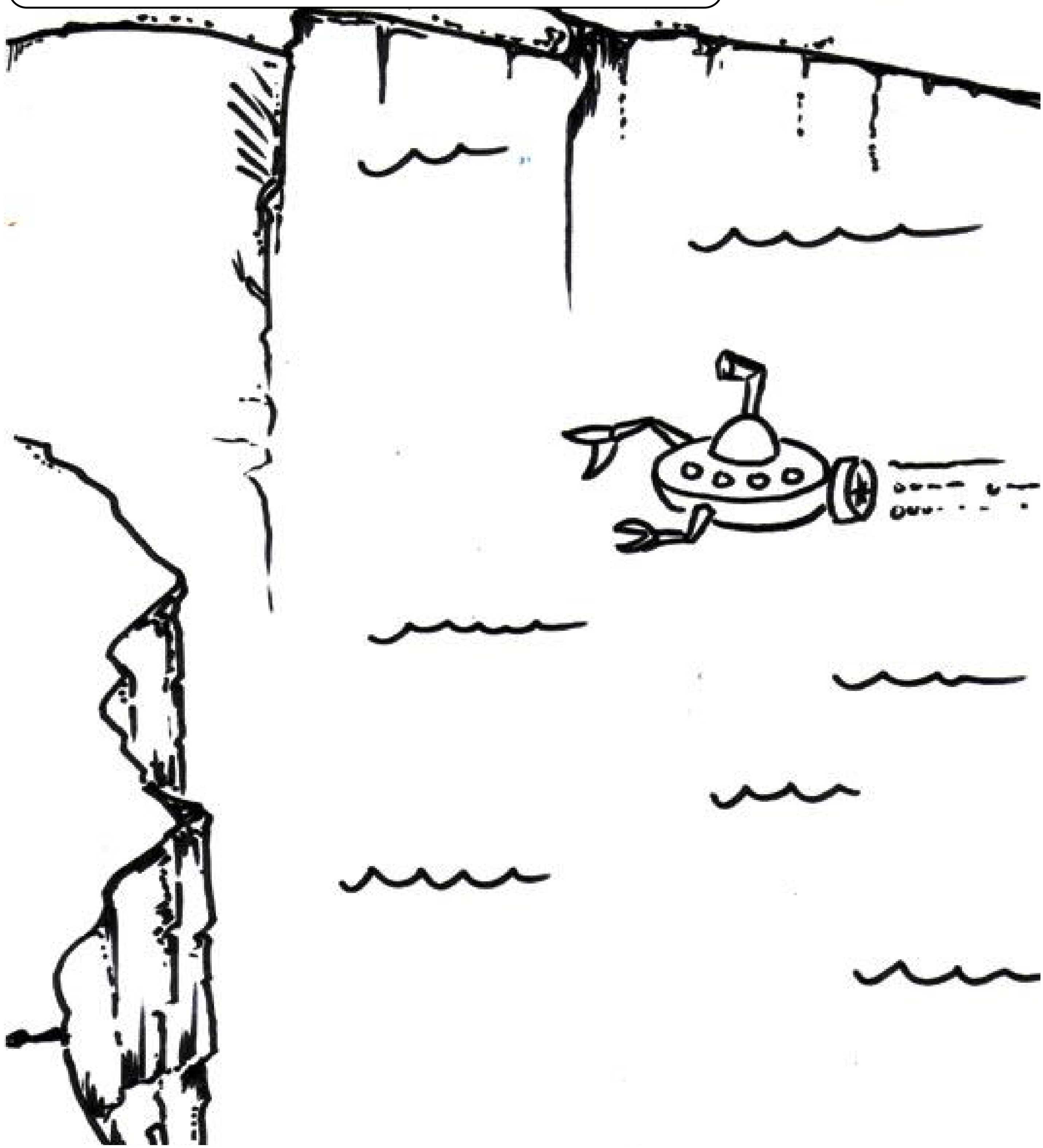
The swash zone brings you to the wet, wave-splashed area of the beach where the tide flows in and out. Small birds called sandpipers follow the waves in and out to find food buried in the sand. Polychaete (segmented) worms and sand crabs thrive in this zone. They are preyed upon by shorebirds, including snowy plovers and marbled godwits.

Plantilla del Mural del Hábitat

La playa arenosa se compone de las olas que se estrellan, las mareas que cambian, y la orilla arenosa.

Habitat Mural Template

The deep sea is a harsh environment where darkness, chilly waters, and intense pressures are found.



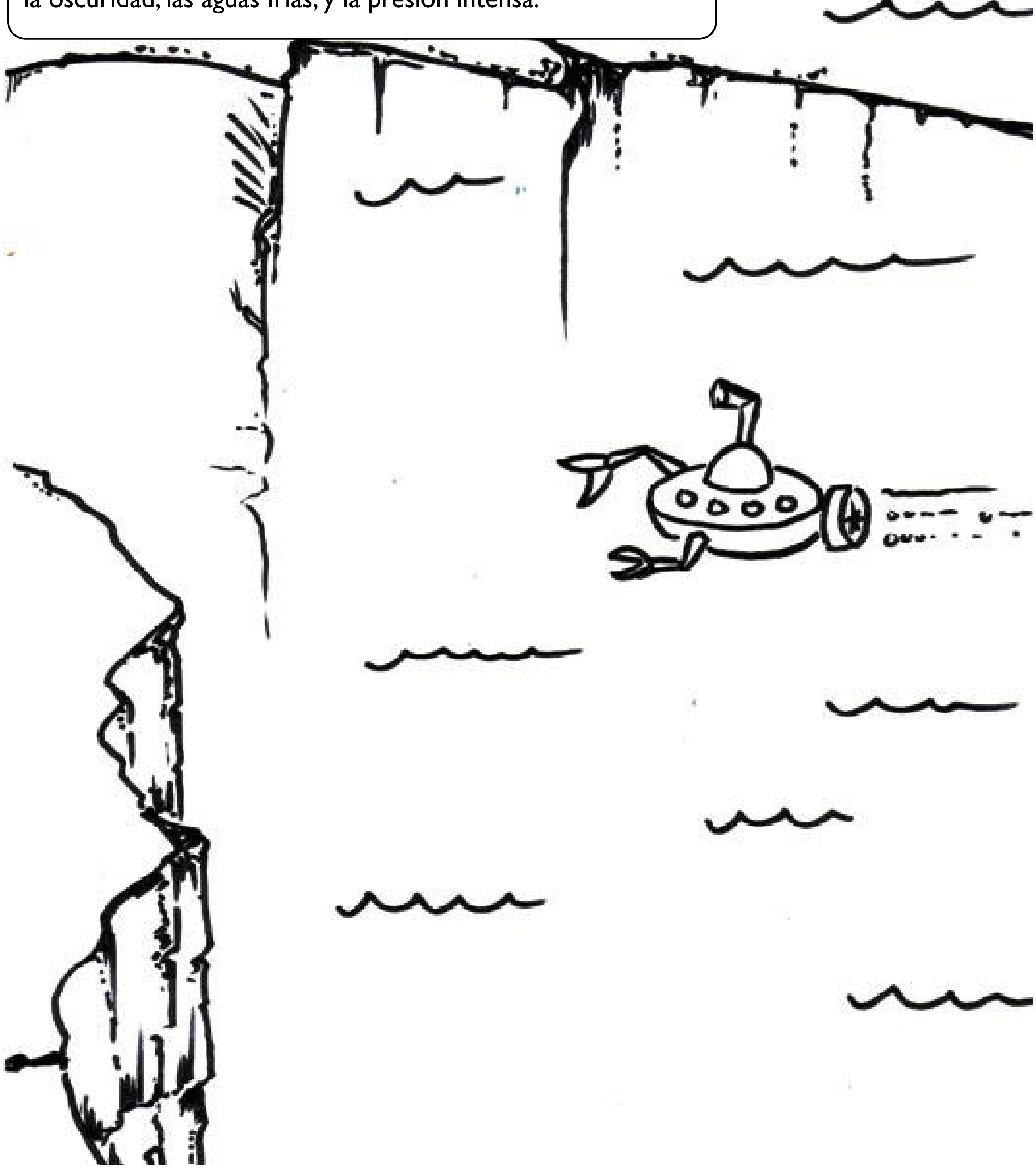
Deep Sea Community

The Monterey Bay National Marine Sanctuary protects a special and unique deep sea community very close to shore. The vast underwater Monterey Canyon begins a steep drop off to great depths just off the coast of Moss Landing in between Santa Cruz and Monterey. It is deeper than as the Grand Canyon in North America, reaching a depth of 3,656 meters (almost 12,000 feet) just 96,561 meters (60 miles) offshore.

Waters deeper than 200 meters (656 feet) are part of the deep sea community. This region is dark and cold and experiences far greater atmospheric pressure than on land. Without sunlight, many animals living here use bioluminescence (the biological production of light) to attract mates or food. Animals like deep-sea anglerfish and the vampire squid have huge mouths they use to capture a meal. Other animals, like the spot prawn, feed on the fallen carcasses of dead animals.

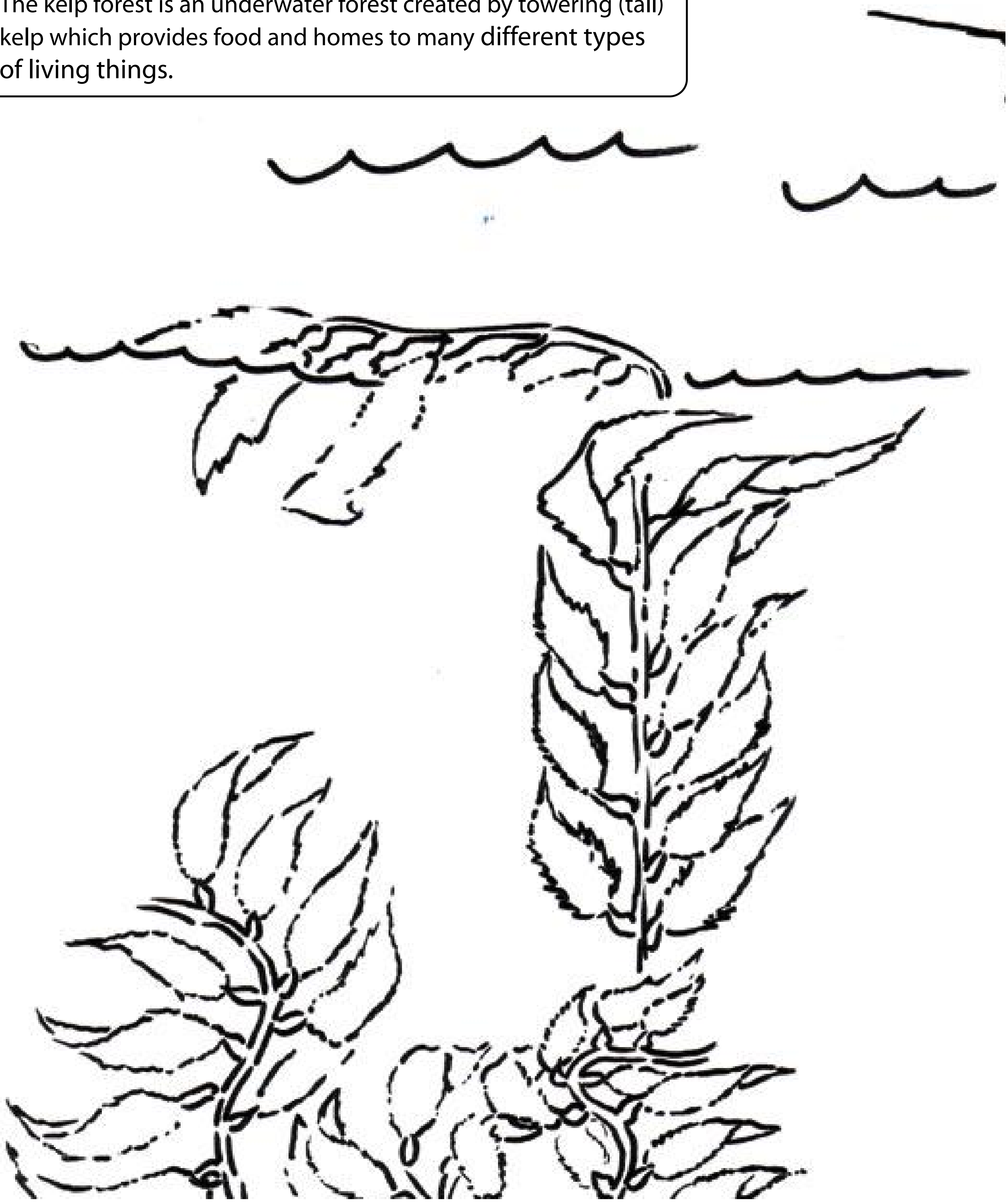
Plantilla del Mural del Hábitat

El mar profundo es un ambiente áspero donde se encuentra la oscuridad, las aguas frías, y la presión intensa.



Habitat Mural Template

The kelp forest is an underwater forest created by towering (tall) kelp which provides food and homes to many different types of living things.



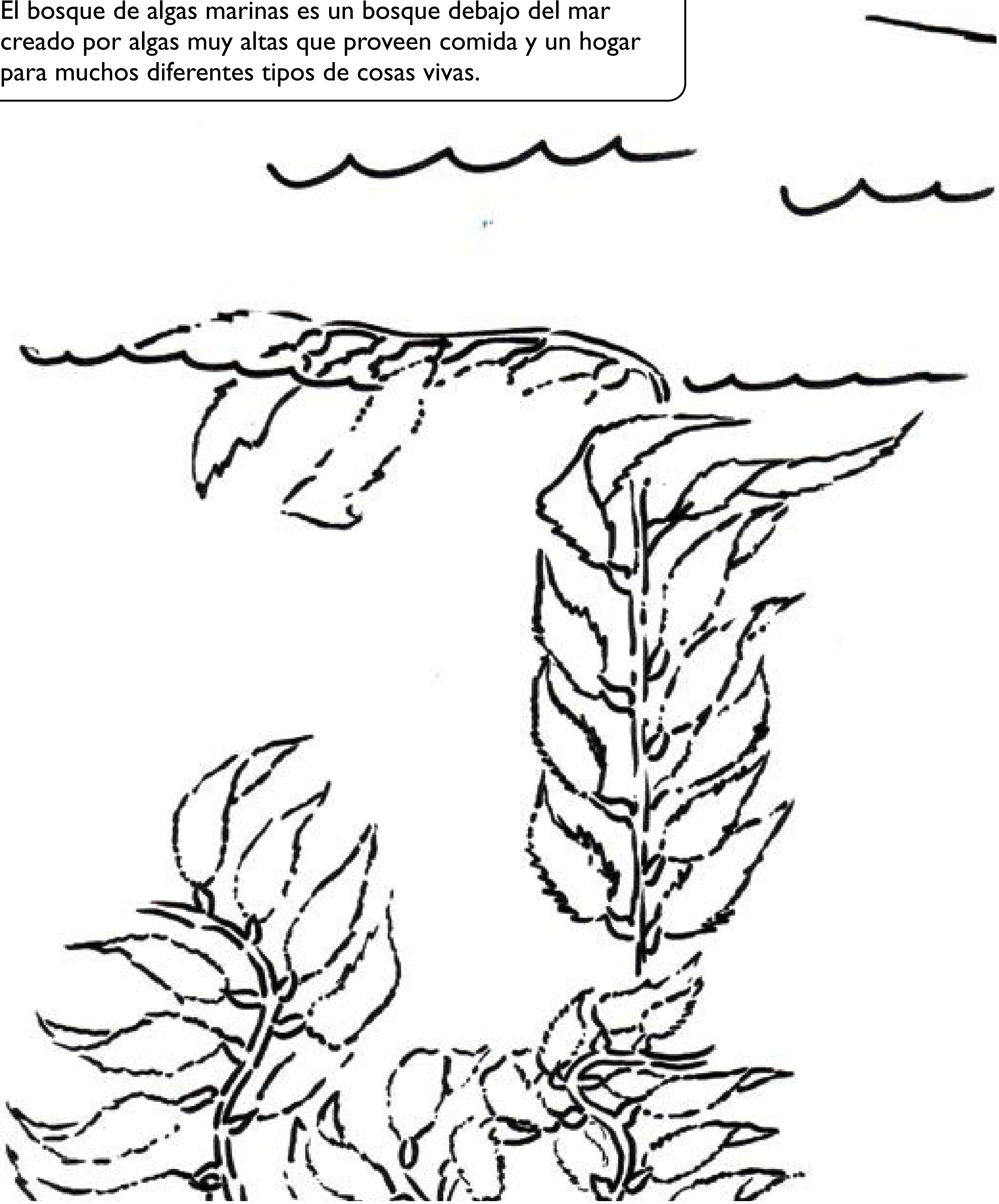
Kelp Forest Community

The rocky shore extends down below the surface of the ocean to the subtidal zone, which is always covered by water. Giant kelp uses a root-like structure called a holdfast to attach tightly to the rocky subtidal floor. Like the trunk of a tree, a long stipe grows from the holdfast upwards towards the surface of the water. When the stipe is long enough to reach the surface of the water, leaf-like fronds fan out on the ocean surface to absorb sunlight and nutrients. Little air sacs, called pneumatocysts help keep the fronds afloat. Cold, nutrient-rich water provides the kelp with nutrients to grow as much as 10 inches per day.

Like the forest community on land, kelp forests provide habitats for many organisms. Some animals, like brittle stars and worms, live in the nooks and crannies provided by the root-like holdfast. Rockfish swim through the trunk-like stipes, feeding on kelp crabs and other animals living on the stipes. Surfperch and sea otters spend time in the nutrient rich canopy of fronds spreading out across the surface of the water.

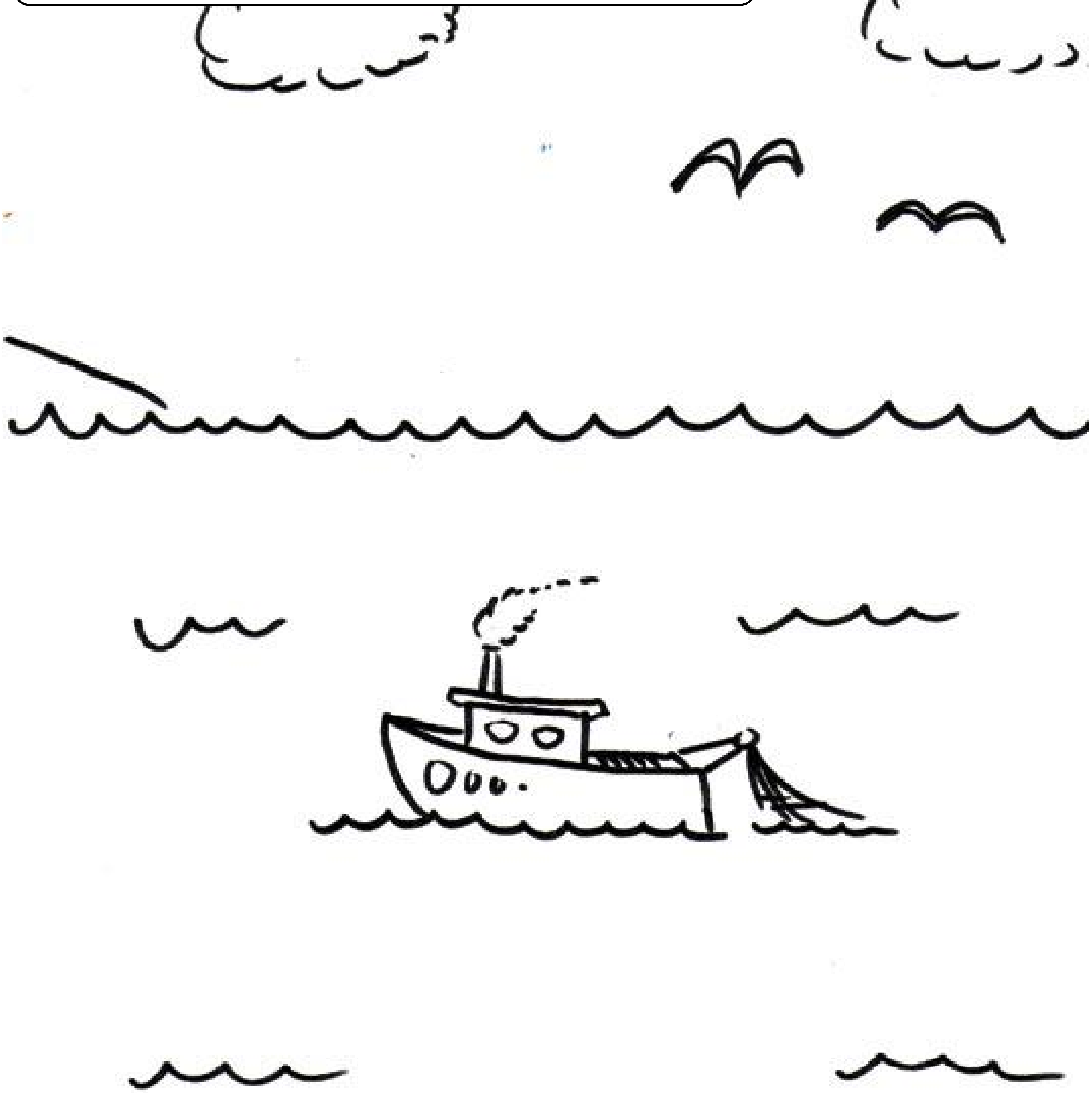
Plantilla del Mural del Hábitat

El bosque de algas marinas es un bosque debajo del mar creado por algas muy altas que proveen comida y un hogar para muchos diferentes tipos de cosas vivas.



Habitat Mural Template

The open ocean is located away from shore and is a wide-open world without boundaries.



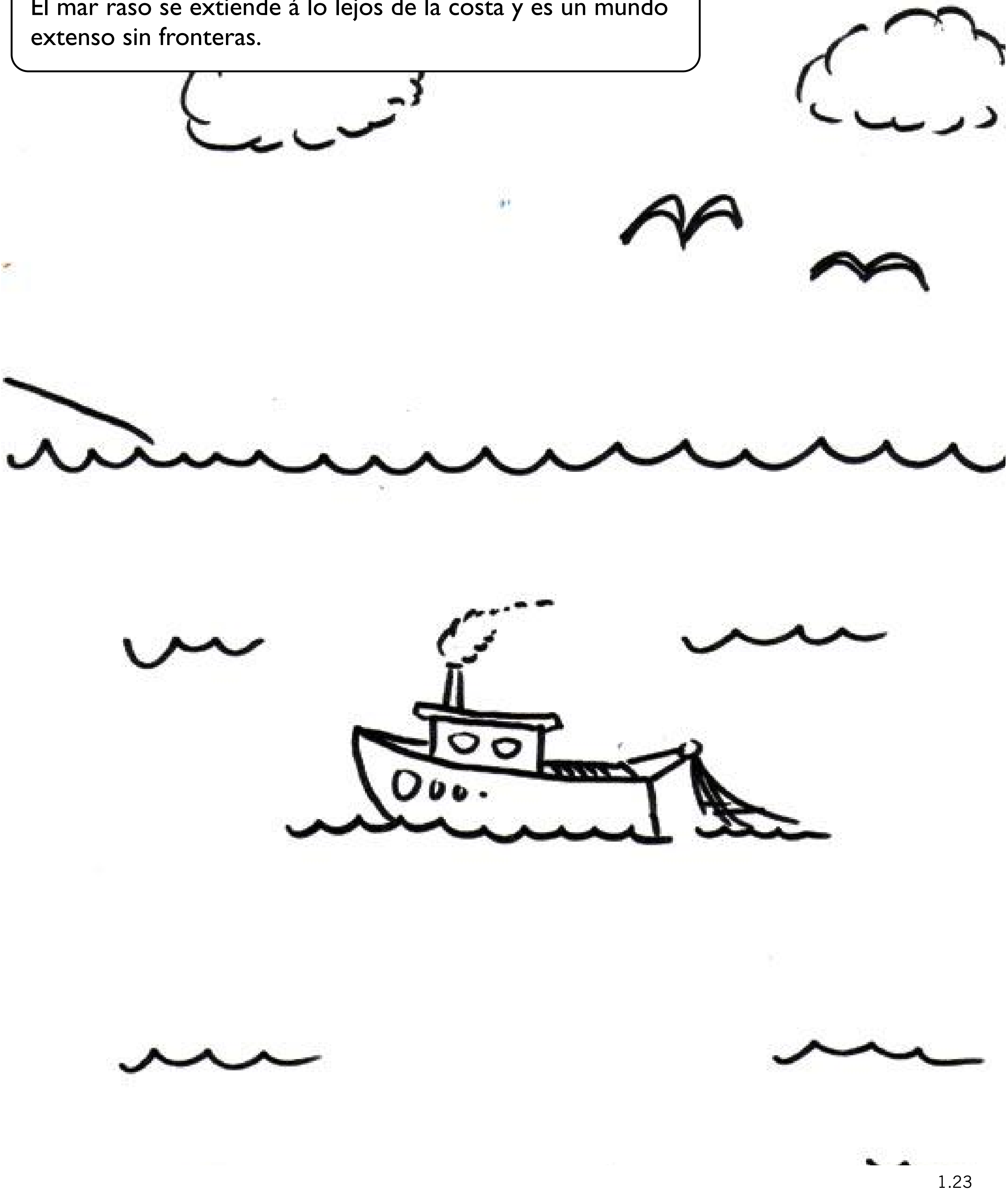
Open Ocean Community

The open ocean is located many miles from shore. There are no crashing waves or changing tides; the open-ocean has no boundaries or places to hide. The sheer force of the current is too strong for most animals to fight against. Instead, these animals flow with the currents. Small, free-floating plants and animals are called plankton. Planktonic plants are called phytoplankton, while planktonic animals are called zooplankton. Although tiny, plankton compose a huge source of food for all other living things in the open ocean.

Free-floating jellies follow ocean currents to feed on plankton. The By-The-Wind Sailor is a small blue jelly that is often blown ashore by strong winds. The ocean sunfish feeds on jellies. Some animals can swim against the ocean currents. These large predators are the ones we love to watch: whales, tunas, and sharks and sea turtles are all examples.

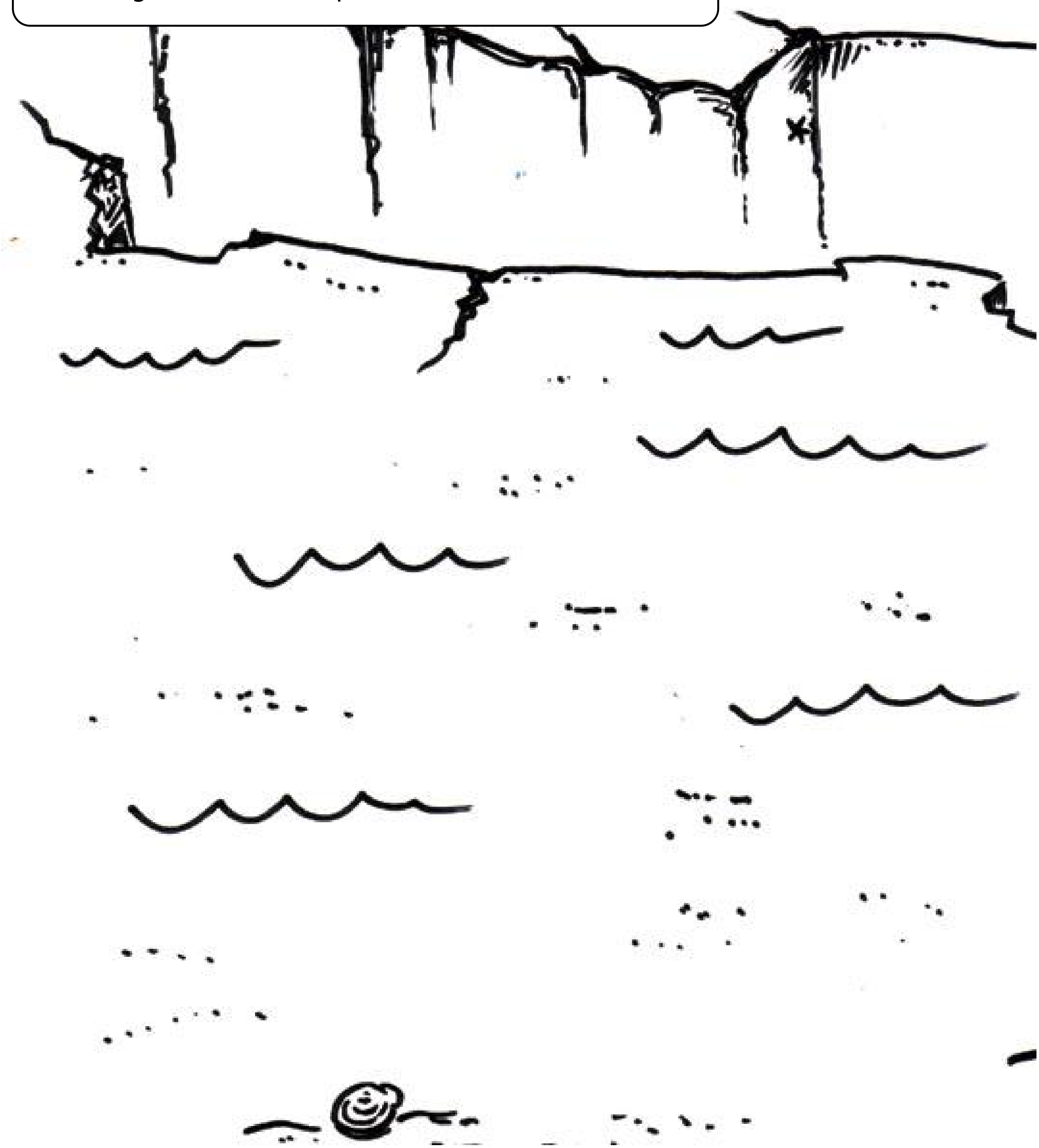
Plantilla del Mural del Hábitat

El mar raso se extiende á lo lejos de la costa y es un mundo extenso sin fronteras.



Habitat Mural Template

Sand gathers under the ocean creating a sandy bottom where organisms live on top of and below the sand.



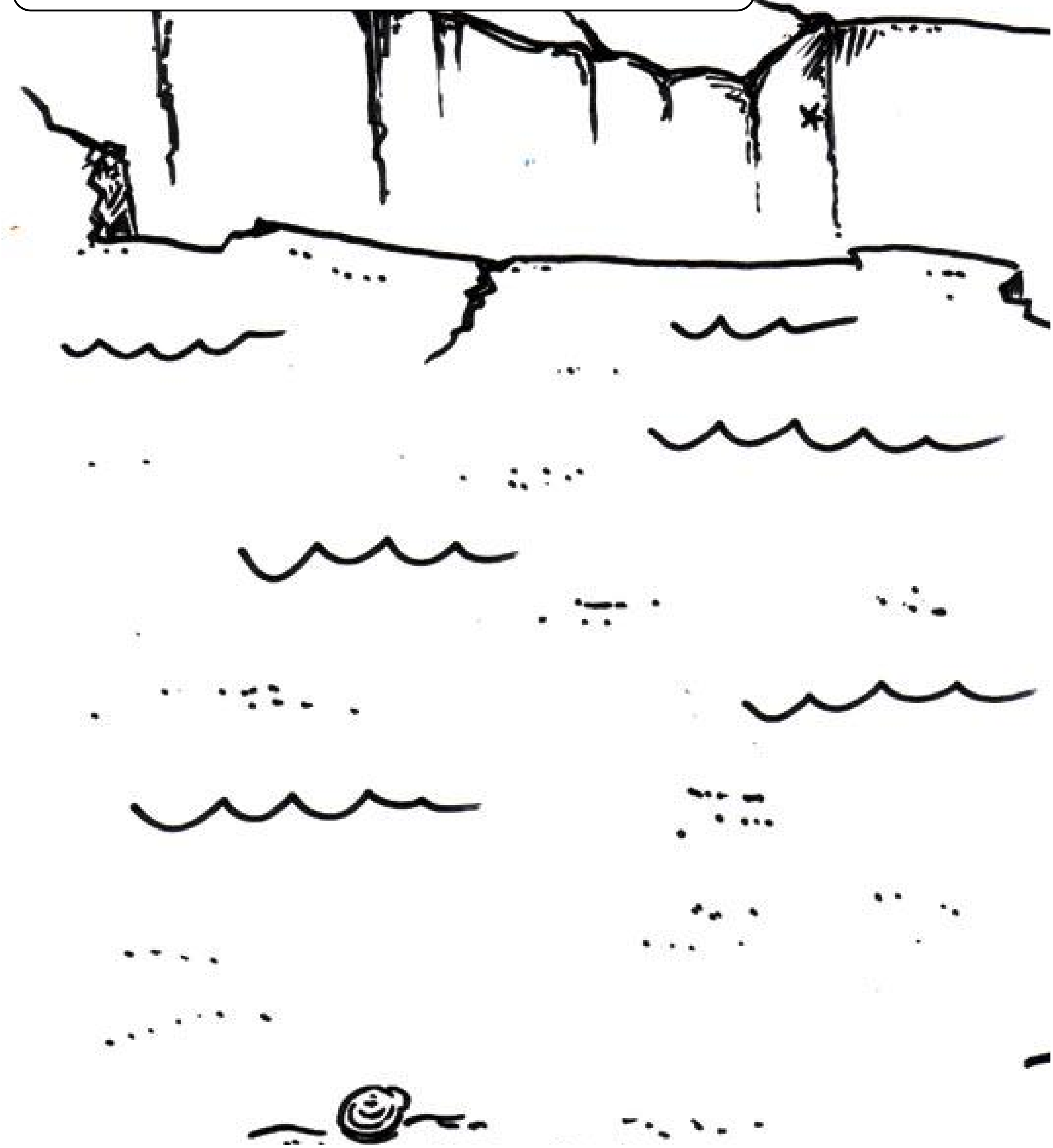
Sandy Seafloor Community

The sandy seafloor is a submerged marine community with a flat sandy or muddy bottom. Sand dollars, sea pens, and brittle stars live on the sandy seafloor. Flatfish like sand dabs and halibut use camouflage to match the surrounding sand and mud.

Seaweeds do not usually grow on sandy seafloors because there are no rocks for their habitat. Animals living here must rely on other sources of food. Many sandy seafloor animals, like sea cucumbers are decomposers. They eat detritus—particles of dead plants and animals.

Plantilla del Mural del Hábitat

La arena se junta en el fondo del mar creando un fondo arenoso donde los organismos viven sobre y debajo de la arena



Habitat Mural Template

Crashing waves, changing tides, and rocky coastline define the rocky shores.

Rocky Shore Community

Rocky shores are found at the junction of where the land meets the sea. The rocky shore is a harsh environment, where waves, wind and sun pound all day. The level of the sea rises and falls twice a day, creating two high tides and two low tides daily. The intertidal zone is a habitat in this community that exists between the highest high tide and the lowest low tide. This is where we find tidepools.

There are many different organisms living in the intertidal habitat. Organisms living here must not only deal with crashing waves and changing tides, they must also compete for space, find a meal, and avoid being eaten. If you look closely at intertidal organisms, you can find body structures that help them survive.

Mussels anchor themselves to rocks using strong, durable fibers called bissel threads. Sea stars and sea urchins hold onto rocks using tiny tube feet lined with suction cups. Abalone have flat shells so waves roll smoothly over them. Other organisms take cover from the waves. Worms hide in seaweed, crabs crawl under rock overhangs, and sea urchins hide in rock holes. Plants and algae, like sea lettuce and Turkish towel get torn and shredded by the waves.

There are predators living in this community too. Gulls feed on small fish and intertidal organisms. Black oystercatchers pick small crabs and other invertebrates from the tidepools. Harbor seals haul out on rocks along the shoreline, feeding on fish and squid.

Plantilla del Mural del Hábitat

La costa rocosa esta compuesta de mareas cambiantes, olas rompientes, y orillas rocosas.

Habitat Mural Template

Watersheds are areas of land that funnel water towards rivers, creeks, streams, and the ocean.

Watershed Community

The hills and mountains in coastal and central California receive water in the form of rain and snow. Water that is not absorbed by the soil, travels downhill to collect in rivers, streams and creeks. These waterways eventually lead to the coast and flow into the sanctuary. Watersheds are areas of land that collect water and funnel it into rivers, creeks and streams. There are eleven major watersheds draining into the Monterey Bay National Marine Sanctuary, adding up to a total of over 6,000 square miles.

Watersheds provide habitats for people and animals. In California, the most concentrated areas of human communities are close to the ocean, in watersheds. Human activities can affect watersheds–toxic materials dumped into creeks and streams affect the fish and wildlife that live in them.

Even though watersheds are not in the sanctuary, they flow into important fresh water habitats like rivers and streams. These waterways eventually flow into the ocean. Keeping watersheds healthy and clean protects habitats, communities and species living in and around them.

Plantilla del Mural del Hábitat

Las cuencas son áreas en la tierra donde toda el agua de las lluvias se junta y escurre hacia ríos, arroyos y al mar.

Habitat Mural Template

Wetlands are areas of land filled or covered by water and neighbored by mud or grass.

Wetland Community

When a river meets the sea, the connection often creates a wetland. Wetlands are flat shallow areas with high soil moisture, often covered with a thin layer of water. Elkhorn Slough (pronounced “slew”), located near Moss Landing in central California, is a large wetland created by the junction of the Salinas River and Monterey Bay. Fresh water from the Salinas River mixes with salty water from the Pacific Ocean to create a unique community with a variety of different habitats. Pickleweed is a plant that thrives on this mixture of fresh and salt water.

Sloughs and estuaries provide protected, calm places for animals to feed and reproduce. The shallow waters slow wave action. Runoff and sediment flow into the wetland during winter rains, adding nutrients to the water. Eelgrass provides a rich food source for many species of animals. The combination of calm, shallow water and rich nutrients provide a perfect nursery area for young animals to hatch and grow. In the spring, leopard sharks, bat rays, flatfish, and many other animals come into Elkhorn Slough to give birth or lay eggs.

Beneath estuarine and slough waters lays a carpet of mud. Burrowing animals like ghost shrimp, fat innkeeper worms, and small fish dig holes in the mud. When the tide comes in, they leave their protective holes to feed. Some become prey to predatory birds like egrets and herons.

Plantilla del Mural del Hábitat

Un humedal es un área de tierra llena de agua con orillas de lodo o hierbas.

Natural Resources Jeopardy

LESSON 1.2

Summary

In this activity, students learn about natural resources, where they come from, and how we depend on them every day. They apply this knowledge by identifying the natural resources used to create objects in the classroom, playing a Jeopardy-style game with natural resource facts, and writing a haiku poem. As an extension, students test their knowledge of marine resources with Level 2 Jeopardy.

Learning Objectives

Students will be able to:

- Describe what natural resources are and give an example of a use for each resource
- Identify the natural resources used in common items
- Describe at least two ways to conserve natural resources
- Learn about marine resources in the Monterey Bay National Marine Sanctuary

Background

Natural resources are naturally occurring materials that are used by humans and other living things. Some natural resources are abiotic or non-living, examples include elements like carbon, hydrogen and oxygen, as well as rocks, metals, gems, sand, water, air and sunlight. Other natural resources are biotic, or made from living things. These include trees and other plants, animals, and soil, which is a combination of rocks, water and decaying plant matter.

Living things need and use natural resources, like water and nutrients, for survival and growth. Plants use energy from sunlight and nutrients in the soil to make leaves, stems and fruits. Animals eat plants and other animals for nourishment and are used for nourishment by other living things, including humans. Natural resources can also be used as raw materials to make other things. Trees are used to create paper products. Foods and spices like cinnamon, coffee, chocolate, and nuts also come from trees or shrubs.

We used to think that our resources were infinite, or never-ending. Now we know that many natural resources are in limited supply, and can be used up. The faster we use natural resources, the sooner we will run out of them. Fortunately, there are things we can do to slow the rate we use natural resources. We can re-use them, replace or renew them, or use fewer of them. By using resources carefully, they will last longer.

Duration

What are Natural Resources?: 15 minutes
Natural Resource Jeopardy Level 1: 20-30 minutes
Natural Resource Jeopardy Level 2: 15 minutes
Natural Resources Haiku: 15 minutes

Teacher Prep

1. Read activity background Photocopy Draw Natural Resources worksheet, one per student
2. Photocopy Natural Resources Jeopardy Level 1 question sheet
3. Photocopy Natural Resources Jeopardy Level 2 (optional) question sheet
4. Gather pens, paper, crayons for drawing activity

Materials

- Draw Natural Resources worksheet, one per student
- Natural Resources Jeopardy Level 1 question sheet
- Natural Resources Jeopardy Level 2 question sheet (optional)
- Pencil and paper for haiku, crayons or pens for illustrating Draw Natural Resources

Natural Resources Jeopardy

LESSON 1.2

Vocabulary

Abiotic
Air
Animal
Biotic
Conserve
Desalination
Elements
Finite
Fossil Fuel
Infinite
Metal
Mineral
Natural
Plant
Protect
Recycle
Reduce
Renew
Replace
Resource
Soil
Sunlight
Sustainable
Water

Activity Extensions

Natural Resources Jeopardy Level 2: Ocean Resources
The Level 2 questions are specific to marine resources that can be found in the Monterey Bay National Marine Sanctuary. This set of questions is more challenging, and could be answered as a class instead of in a game format.

Your "environmental footprint" is the calculated amount of resources you use in your life. Your "footprint" can be calculated by answering a series of questions such as how far you drive, if you buy locally produced food and goods, and even the types of food you eat. Calculate your own environmental "footprint," or impact on the world by going to http://www.myfootprint.org/

Some natural resources can be replaced or renewed. Trees can be planted to replace those that have been cut down. Fishing activities can be slowed or stopped until fish have reproduced and the population grows. We refer to these examples as renewable resources. Other resources are nonrenewable.The earth contains only a finite amount of metal, ore and fossil fuels. When these materials are used up, they will no longer be available. Conserving natural resources, by reusing or recycling them, will make them last longer.

Some depleted resources can be replaced with substitutes. At one time, there was enough fresh water to support the residents of California. As California's population grew, there was no longer enough fresh water to support all the people living in the state, and water was imported from other places to keep up with the demand. Today, the technology exists to remove the salt from seawater (desalination) as replacement for fresh water. Desalination of seawater may become an important way to provide fresh water, but there is also a concern that using seawater to make fresh water could affect other living things in the ocean. Conserving water, by using less, would reduce the effect that desalination might have on sanctuary resources.

In the marine environment, examples of natural resources include the water, rocks and minerals, kelp, plankton, fish, and marine mammals. Some resources can be harvested for human use as long as they are able to sustain their populations. For example, fishermen harvest fish using nets or by hook and line. Crabs are collected in baskets or traps, and shellfish are removed from rocks. Kelp is harvested and dried for food, and is used as an ingredient in other products. The Monterey Bay National Marine Sanctuary is required to conserve and protect natural resources in the sanctuary. Part of our job is to encourage wise use of marine resources.

Activity Procedure

What are Natural Resources?
Start a brainstorm discussion with your students by describing what natural resources are: ***"Naturally occurring materials that are used by humans and other living things."*** Tell students the things we use everyday are composed of natural resources – in fact, even people, plants and animals are composed of natural resources! Start a list on the board with a description of the natural resources used by people animals, and plants. Then have students select objects in the room and try to determine what natural resources they were made from. Point out to your students that the same natural resources occur on the list again and again. What are they? **Air, water, sunlight, minerals, metals, fossil fuels, plants, animals, soil.** These are considered the most basic natural resources, from which all other things are made.

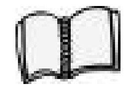
Natural Resources Jeopardy

Now ask your students what they might do if natural resources disappeared. What if there were no more cotton, leather, metal, chickens, or gasoline? What would life be like, or would there be any life at all? Point out how much we depend on natural resources for our quality of life. The United States is a wealthy country, which means we can afford to enjoy many luxuries, all made from natural resources. Other people in other countries do not use as many natural resources as we do. If we had less, would we appreciate them more?

Explain to your students that the Monterey Bay National Marine Sanctuary is required to protect and conserve natural resources. Ask your students for ideas on things they can do to conserve natural resources, including:
• Use less
• Don't throw it away
• Use renewable resources
• Recycle
• Use it again

Distribute the handout, Draw Natural Resources to each student. Have students draw and label examples of natural resources in each of the spaces. Above each drawing, have students write a sentence about that resource. For example: *Animals, plants, and humans need water to survive.*

Natural Resources Jeopardy Level 1
Group students into teams of four. They can choose a name for themselves (for fun, they may use a name of one of the natural resources, such as, Water Wizards, or Soil Superheroes). Assign a reader to read the question, and a referee (the teacher is the best referee). Hand the list of Jeopardy Level 1 questions to the questioner.
Begin the game. Each question has a point value from 1-3. Have the questioner announce the point value followed by a question. For example, "For one point, name the natural resource we can't see or feel, but is essential for our survival." Students will talk within their groups to come up with an answer. The first group to raise their hand gets a chance to answer the question. If they give an incorrect answer, then the group who raised their hand second gets to try, and so on.
Keep track of the groups' scores on the board under their team name. The game is finished when you run out of time or questions. Optional: provide a prize for winning team.



Journal Prompt Closing Activity

Natural Resource Haiku
Students write a haiku about a natural resource or natural resources in general. **Haiku** is a traditional Japanese poem or verse made with 17 syllables on three lines. The first and third lines contain five syllables and the second contains seven. Let your students be as creative as they like. Haiku poems may be about the natural resources they learned about, or about conserving natural resources. Students may illustrate their haiku with crayons or pens.
Example:
A plant needs water
But it also needs sunlight
To give us clean air

Draw Natural Resources

Natural Resources
Recursos Naturales

What are examples of natural resources? Draw and label them here.
Dibuja cada uno de los recursos naturales y escribe su nombre.

1. Minerals	**2.** ________	**3.** ________	**4.** ________
5. ________	**6.** ________	**7.** ________	**8.** ________

Natural Resources Jeopardy, Level 1

Questions are valued at one to three points depending upon difficulty. Give full credit for complete answers, or you may provide partial credit as appropriate. If students give specific examples, such as "tree" encourage them to tell you which natural resource their answer falls under,
any other correct answers for that point value, then give points to both students.

Points	Question	Answer
1	What is the natural resource we can't see or feel, but is essential for our survival?	Air
1	What natural resource do you conserve when you fix leaky faucets in your house?	Water
1	What natural resources are roads and highways made from?	Minerals (gravel, asphalt, concrete)
1	What natural resource is motor oil made from?	Fossil Fuel
1	Give an example of a renewable natural resource.	Plants or Animals
1	Give an example of a non-renewable natural resource.	Minerals, Metals or Fossil Fuels (oil, natural gas)
1	What natural resource is the energy source for plants?	Sun
1	Which natural resource covers 71% of our planet?	Water
1	What natural resource provides nutrients for plants?	Soil
1	The color in fireworks is made from what natural resource?	Minerals
1	What kind of marine resources do we eat?	Animals (fish, shellfish) and plants (kelp)
2	When you recycle glass bottles, what natural resource do you save?	Sand, a Mineral
2	What natural resource do you conserve when you recycle cans?	Metals (Aluminum or steel)
2	When you walk or ride a bike instead of driving a car, you reduce your use of what natural resource?	Fossil Fuel (gasoline)
2	Using a rake or broom instead of a gas leaf blower reduces the use of what natural resource?	Fossil Fuel (gasoline)
2	Recycling cardboard, junk mail, and paper packaging saves what natural resource?	Plants (trees)
2	What natural resource do you conserve when you use paper bags again and again?	Plants (trees)
2	These natural resources are responsible for California's agriculture.	Soil, Sun, Water or Plants
2	Recycling used motor oil conserves what natural resource?	Fossil Fuel
3	Whales migrate to the Sanctuary. What natural resources do they consume?	Plants, animals, water
3	What living natural resources could be harmed by pollution?	Plants and Animals
3	In the Sanctuary and its watersheds live two of the tallest natural resources in the world. What are they?	Giant Kelp and Redwood Trees (both Plants)
3	What natural resource is saved when you turn off unused lights, computers, stereos, and televisions?	Fossil Fuel or Electricity
3	Hybrid cars use a blend of energy resources for power. What natural resource do hybrid cars conserve?	Fossil Fuel (gasoline)
3	Name five natural resources we have discussed today.	Minerals, Metals, Water, Air, Soil, Plants, Animals, Fossil Fuels
3	Many natural resources depend upon other natural resources to grow. Can you name one natural resource and the natural resources it needs?	Animals and people need minerals, water and air. Plants need sunlight, water and soil
3	The Monterey Bay National Marine Sanctuary was created to protect natural resources in the ocean. Can you name three natural resources occurring in the sanctuary?	Minerals, Metals, Water, Air, Soil, Plants, Animals, Fossil Fuels

Natural Resources Jeopardy, Level 2

This g
Be sure to
it, then give them the answer.

Points	Question	Answer
1	If you order calamari at a restaurant, what ocean animal are you going to eat?	Squid
1	Sushi roll wrappers are made of Nori. What kind of natural resource is Nori?	Kelp, an alga related to plants.
1	What kind of marine animal waste is used as fertilizer?	Seabird Guano
1	What did people in cold climates wear that was warmer than wool or cotton?	The hides of seals and sea otters. Now protected, these animals are no longer hunted in most countries.
1	What Pacific mollusk is considered a delicacy in Japan?	Abalone, a type of snail (Animal)
1	What is the ingredient used to make ice cream smooth that comes from the sea?	Carrageenan, a compound extracted from kelp
1	What ocean fish is an important ingredient in tuna casserole?	Tuna
1	What was used for lighting lamps before kerosene and gasoline?	Whale Oil
2	What tiny ocean organism is responsible for producing 70% of the world's oxygen?	Phytoplankton
2	How do we get fresh water from the sea?	Desalination
2	Where does the calcium in vitamin supplements come from?	Coral and the shells of clams and other shellfish (Animals)
2	Chondroitin is a nutritional supplement that reduces joint pain. What ocean animal does it come from?	Sharks
2	In the 1800's women wore corsets (a type of girdle).What marine resources were some corsets made from?	Whale baleen
2	Before metal, what did Native Americans use to make fish hooks?	Shells (from animals) and Chert (a type of rock)
2	Neuroscientists use extra large nerves from this animal in experiments to better understand how human nerves work.	Squid
2	What kind of shell was used as currency (money) by Native Americans?	Olive snail shells
2	What animals have been trained by the military to detect explosive devices and other dangers?	Dolphins and sea lions
3	Diatomaceous Earth comes from what marine organisms?	Diatoms (microscopic animals)
3	Torpedoes were designed to imitate the body shape of what marine animal?	Tuna
3	How do we use the ocean for providing electricity and power?	Harness ocean currents and tides
3	What shellfish produces a strong waterproof fiber that scientists are still trying to copy?	Mussels produce bissel threads that can attach to wet rocks
3	What kind of animal was used as a musical instrument (a kind of trumpet) in some Native American ceremonies here in central and southern California?	Whelk (a type of snail) Conchs were also used

Coralito's Bay Book Club

LESSON 1.3

Summary

As a "book club," students take a reading journey to explore the hidden wonders of the Sanctuary in this delightful story written by Juan Felipe Herrera, a nationally recognized Chicano poet. As they explore the Monterey Bay National Marine Sanctuary with Coralito, students learn the importance of clean water to the Sanctuary and its diverse inhabitants. Students learn active listening strategies and participate in a group discussion about the story, then write a sequel or their own adventure stories.

Learning Objectives

Students will be able to:

- Name three habitats in the Sanctuary and species that live in each habitat
- Correlate the significance of clean water to ocean life and clean air to humans
- Practice reading strategies designed to enhance comprehension and retention
- Describe ways to maintain and improve the health of the ocean and watersheds

Background

Coralito's Bay is a Spanish-bilingual children's book that chronicles the story of a young boy's imaginary underwater adventures through the Monterey Bay National Marine Sanctuary. *Coralito's Bay* is written by nationally recognized Chicano poet and author Juan Felipe Herrera and responds to a need for expanded multicultural education about marine and coastal environments.

Based on the life of a migrant family, Coralito's dream-like journey in his father's adapted flower truck shows the young boy the natural wonders of living in the Sanctuary, and how important clean waters are to its inhabitants. Coralito learns that the ocean needs a clean and healthy environment just like he does.

Duration

Reading *Coralito's Bay*: 30 minutes

Coralito's Bay Book Club: 20 minutes

Closing activity: 20 minutes

Teacher Prep

1. Read *Coralito's Bay*, including the information after the story
2. Photocopy *Coralito's Bay* Book Club worksheets, one per student

Materials

- *Coralito's Bay* Book
- *Coralito's Bay* Book Club worksheet
- Pencils
- Journals

Coralito's Bay Book Club

LESSON 1.3

Vocabulary

Book Club
Habitat
Kelp Forest
Monterey Bay National Marine Sanctuary
Outer Bay
Pollution
Reefs
Sandy Shores
Shore
Wharf

Activity Procedure

Coralito's Bay Book Club

1. Explain to your students that a book club is formed by a group of people all reading the same book at the same time. They get together periodically to discuss the story. People like to share their ideas and find out if others interpret the story the same way they do or differently. These discussions help them understand the story, and get more from its meaning. Your class is going to be a book club, and the book they are going to read and talk about will be *Coralito's Bay*. Suggest that students use some of the following strategies to help them better understand and engage in the story. Briefly describe these active reading strategies before starting to read.
   - Connect: Think of similar experiences you have read about, or seen. Keep these connections in mind as you read or listen to the story.
   - Visualize: Create a picture in your head as you read or listen to the story. Imagine what the characters look like, act like, and let a "movie" run through your head as the story continues.
   - Predict: Guess what will happen next when you are reading or listening to a story. Your prediction can be based on a feeling you have or a clue you read earlier. Remember your prediction as you read on to see what actually happens next. Were you right? If not, what clues can you look back on that might have helped you to predict more accurately?
   - Question: Ask yourself questions (or ask the teacher) as you read or listen to the story. If something doesn't make sense, stop and think about it, read it again, and/or ask someone for help. Try looking back at what you have already read or heard to see if you can find answers to your questions.
   - Clarify: Read slowly and carefully or reread sections to help you better understand concepts or ideas.
   - Evaluate: After the story, evaluate what you have read or heard. Ask yourself these questions: What would I do in this situation? What do I think of the characters' actions, decisions, etc.? Did the author do a good job telling the story? What is the author's message? Do I agree with their beliefs?

2. Have students sit quietly in a circle. Assign a different student to read each page, or you can read the story to them.

3. Hand out a *Coralito's Bay* Book Club worksheet to each student, and tell students the table on the back of the worksheet will help them remember the different animals that Coralito encounters on his journey. During the reading, pause from time to time to allow students to look at the table to find the habitats and animals they are reading about.

4. After the story, open the group discussion. Tell students that in a book club, everybody has a chance to voice their opinions, and all opinions are treated with respect. Different people get different messages from what they read, depending on their own life experiences and how closely they follow the story. Use some of these prompting questions:

- Did you like this story?
- What was your favorite part of the story?
- Did this story seem believable? Was it meant to be believable?
- What habitats did Coralito encounter during his journey? Are these real habitats?
- How do all the marine creatures depend on a clean and healthy environment to survive? What do you think the author's message is? What evidence, or clues, did you hear that make you think this?
- How can people make a difference through individual and community actions to improve and maintain the health of the watershed and ocean? (Use page 39 in *Coralito's Bay* for reference.)

Journal Prompt Closing Activity

On their worksheet, have students write a sequel to *Coralito's Bay* outlining other places, creatures or habitats that Coralito could encounter in his next journey, and any types of pollution that could affect the ocean and its inhabitants, or even humans. Or, encourage students to write their own adventure story. Give students the option of illustrating their story and provide more paper, if needed.

Activity Extensions

Have students write their own adventure story with a conservation message. Use one of the habitats described in the book for ideas. Or, write a story as a class and have different students illustrate the pages.

“Coralito’s Bay” Book Club

Now that you have read the book, you can write and draw some fun ideas of your own! Choose one of these topics to write about below:
¡Ahora que has leído el libro, puedes escribir y dibujar unas ideas divertidas! Elige unos de estos temas para escribir:

1. Write a sequel, a story that follows what happens in *Coralito’s Bay.* Describe other places, creatures, or habitats that Coralito could meet in his next journey. What are some types of pollution that could harm these places and the animals and plants that live there? (For example, Coralito could go up into a river like a salmon, or into a wetland like Elkhorn Slough.)
Escribe una continuacíon, una historia que sigue el cuento de “La Bahía de Coralito”. Describe otros lugares, animales y habitates que Coralito puede conocer en su próximo viaje. ¿Qué tipos de pollución pueden dañar los habitates, animales y plantas que viven allí? Por ejemplo, Coralito puede entrar un río como un salmon o tierra pantanosa como Elkhorn Slough.

2. Create your own adventure story in the Sanctuary, include a conservation message and actions you can take to create change in your school, community, or state.
Cree su propia historia de aventura en el santuario, incluya un mensaje y las acciones de la conservación que usted puede tomar para crear el cambio en su escuela, comunidad, o estado.

Habitats & Species from Coralito's Journey

Habitates y especies del viaje de Coralito

Check each habitat and species as you hear them when your teacher reads the story.
Marca cada hábitat y especie cuando su maestro lee la historia.

Habitat *Hábitat*	Species *Especie*
Shore *La Orilla del Mar*	Acorn barnacles / *Percebres bellotas* Seastars / *Estrellas marinas* Mussels / *Mejillones* Gobies / *Gobios* Sea hare / *Liebre de mar* Copepods / *Copépodos* Amphipods / *Amphípodo*
The Wharf *El Wharf*	Mussels / *Mejillones* Sticky barnacles / *Percebes pegajosos* Anemones / *Anémonas*
Kelp Forest *Bosque de Algas Gigantes*	Kelp / *Alga gigante* Blue rockfish / *Chancharros azules* Sea otter / *Nutria marina* Crab / *Cangrejo*
Outer Bay *Bahía Exterior*	Blue shark / *Tiburón azul* Squid / *Calamares* Blue whale / *Ballena azul* Krill /*Krill*
Reefs *Escollo*	Strawberry anemone / *Anémonas de fresa* Bull kelp / *Alga marina de toro* Leather stars / *Estrellas de cuero* Red algae / *Alga roja* Orange sponge / *Esponja anaranjada* Hydrocoral / *Hidrocoral*
Sandy Shores *Orillas Arenosas*	Purple olive snails / *Caracoles olivos violetas* Moon snails / *Caracoles de luna* Sanddabs / *Platijas americanas* Sea pens / *Plumas de mar* Hydromedusa / *Hydromedusa*

Modeling the Monterey Canyon

LESSON 1.4

Summary

As demonstrations or hands-on activities, students observe two geological models representing theories of how the Monterey Canyon was formed. Students then build their own clay model of the Monterey Canyon based on a three-dimensional map, and display species in their submarine canyon habitats.

Learning Objectives

Students will be able to:

- Explain how geologic formations change over time
- Explain how scientists believe Monterey Canyon was formed
- Explain how the Monterey Canyon contributes to biodiversity

Background

Formations on Earth, both above and below water, have changed over time and continue to change. The changes are not noticeable from day to day, but if you could peek at the Earth millions of years ago, it would look drastically different. Two primary forces have shaped the Earth's crust, tectonics and erosion. Tectonics changes the outer layer of the Earth's crust through the slow movement of major sections, called tectonic plates. Erosion changes the shape of land (topography) by the action of wind, water, or ice.

Submarine canyons are long, narrow, steep-walled undersea valleys. Monterey Bay's submarine canyon is one of the deepest canyons along the continental United States, plummeting to a depth of almost 3,656 meters (12,000 feet) just 96 kilometers from shore (60 miles offshore). The canyon provides an abundance of habitat and attracts an array of deep water and oceanic wildlife. Dense swarms of krill (shrimp-like crustaceans) numbering in the millions, live along the canyon walls, attracting endangered blue and fin whales. The canyon edge provides a feeding area for Pacific white-sided dolphins, northern right whale dolphins, Risso's dolphins, Dall's porpoise, and possibly the blue shark. Studies of the seafloor community of the canyon indicate a considerable diversity of organisms, including sponges, gorgonians, sea stars, crinoids, and sea urchins. The open waters of Monterey Bay support oceanic species of fishes, birds, and marine mammals.

The origin of the Monterey Canyon, first described in 1897, has baffled scientists for years. Scientists believed a mighty river would be needed to erode such a vast submarine canyon. However, no large river empties into Monterey Bay today, leaving scientists perplexed. When the theory of plate tectonics became widely accepted, a new idea regarding the origin of the Monterey Canyon arose. Scientists now believe plate tectonics on the San Andreas Fault might have moved the Monterey Bay and its canyon

Duration

Water Erosion Theory Demonstration: 15-20 minutes (hands-on activity 30-40 minutes)
Plate Tectonic Theory Demonstration: 10-15 minutes (hands-on activity 20-25 minutes)
Modeling the Monterey Canyon: 30-50 minutes

Teacher Prep

1. Read activity background
2. Look at how much time you have and whether parts one and two will be done as a demonstration (30-40 minutes for both), or as hands-on student activities (40-60 minutes for both), or not at all. Part three can be done independently of parts one and two, and should be done as a student hands-on activity (30-50 minutes)
3. According to which activities you will be doing, gather materials and photocopy worksheets (see Materials)

Modeling the Monterey Canyon

Materials

Water Erosion Theory Demonstration:
(For hands-on activity, collect one set of these materials for each group of four)
- Deep tray (three to four inches deep)
- Pitcher with water
- Wet sand, enough to cover up to two inches of the tray
- Small and medium rocks
- Drop cloth to catch spills if done inside

Plate Tectonic Theory Demonstration:
(For hands-on activity, collect one set of these materials for each group of four)
- Two small wooden blocks (about three inches wide, four inches long, and one inch thick)
- Enough sand paper to cover the blocks

into where it is today, just offshore of Moss Landing, right in the center of Monterey Bay. The Pacific Plate has been moving northward, and the North American Plate has been moving southward. Twenty-one million years ago, the Monterey Canyon was 350 miles south, near where Santa Barbara is now!

Erosive forces called "turbidity currents" within the Monterey Canyon sculpted the canyon. Turbidity currents are flows of water filled with sediment. The currents begin when sediment shakes loose from the mouth of the canyon or from the canyon walls. Like an avalanche of snow down the side of a mountain, turbidity currents of sediment speed down the walls of the canyon. As the sediment-filled turbidity currents flow downhill, they scour the surface of the canyon walls, scraping away more sediment. This scouring process continues to erode and cut the Monterey Canyon today, as it continues moving slowly northward.

Activity Procedure

Teacher Tip: This activity is divided into three parts. According to how much time you have, you can do all three as student hands-on activities, or parts one and two as a teacher demonstration only. If you have less than one hour, do only part three (Modeling the Monterey Canyon). You may also do parts one and two on one day, and part three on another.

Water Erosion Theory Demonstration

Note: This activity is described as a teacher-led demonstration; for a hands-on student activity, break your class into groups of four and have the students make the model and conduct the activities at their separate stations. This will require you to obtain enough trays, sand, rocks, and pitchers for all the groups.

1. Set up this demonstration on a table for easy observation. You may need to do it outside, or use a waterproof tarp to catch spilled water.
2. Have a large tray filled with wet sand (but not standing water) about 2 inches deep with a few very small and medium rocks mixed in.
3. Set the tray up on a slope, such as a book or a block, so that one end is 2 to 3 inches above the other. Place a bucket at the lower end to catch water as it spills over.
4. Tell students: Water is a powerful force that can cut channels into the land. When rivers flow over land they pick up dirt and small rocks and carry them down stream, causing erosion. Stream erosion is one of the major forces creating the Grand Canyon, and it contributed to the formation of what is now the submarine Monterey Canyon. Watch how erosion works.
5. Fill the pitcher with water, and slowly pour it in one spot on the elevated end, allowing the water to form a small stream down the sand.
6. Watch as the water cuts a path into the sand winding around the rocks and taking sand grains with it. Point out how the sand moves with the water through the channel it has formed.

Modeling the Monterey Canyon

LESSON 1.4

Plate Tectonic Theory Demonstration

1. Briefly review the concept of tectonic plates and how they move by showing them an illustration of the tectonic plates of the earth (Figure 1.4.1). The surface of the earth is broken into seven big plates and twelve small ones. These plates are constantly moving very slowly (.5 to 1 cm per year). Plate edges meet all over the earth. The edges of two plates meet right along the coast of California—the North American Plate and the Pacific Plate. These two plates move past each other, like rubbing shoulders. This movement causes fractures, or faults, in the land.
2. Explain to students how a strike-slip fault works (Figure 1.4.2). Wrap two blocks in sandpaper with the rough side facing out. Place the blocks together and try to slide them past each other. Have students try, too. Lightly, then with force.
3. Explain how the blocks do not easily slide against each other until enough force is applied that it overcomes the resistance of the sand paper. This is similar to how rocks in the ground work. Force from the movement of tectonic plates builds up in the earth along faults until the rocks and soil can no longer withstand the force and break. The result is the movement of the ground in an earthquake.

Modeling the Monterey Canyon

1. Explain that the two concepts we have just explored, tectonic plates and erosion, have interacted over millions of years to create the Monterey Canyon.
2. Show students the picture of the Grand Canyon (Figure 1.4.3) to compare with the Monterey Canyon map (Figure 1.4.4) . The shapes of the Grand Canyon look similar to the Monterey Canyon with sharp drop-off, steep canyon sides, and very deep channels.
3. Show students the poster of the *Grand Canyon of Monterey Bay*. Tell students to look at the canyon species up close, and notice the different depths that each species inhabits.
4. Divide students into groups of four. Hand out copies of the topographic map of the Monterey Canyon, a copy of Modeling the Monterey Canyon worksheet, a block of clay, tape, a ruler, and a small container to each group. Explain to students that they will use these materials to build a clay model of the Monterey Canyon.
5. Help students follow the instructions on their worksheet.

Modeling the Monterey Canyon:
(For each group of students)

- One large block of clay
- One small plastic container about 4 cm deep, 12 cm wide, and 20 cm long
- Toothpicks (about 20 per group)
- Scissors
- Rulers
- Paper to cut
- Pens
- Scotch tape
- Copies of Modeling the Monterey Canyon worksheet
- Copies of topographic map of the Monterey Bay canyon
- Grand Canyon of Monterey Bay poster (provided in kit)
- Monterey Canyon clay model example

Vocabulary

Erosion
Fault
San Andreas Fault
Seafloor Community
Strike-slip Fault
Submarine Canyon
Tectonic Plates: Pacific and North American
Turbidity Currents

6. Bring all students back together and have some of the groups share their responses on their worksheet.
   a. If you were a scientist, how would you go down to these great depths?
   b. What tools would you use?
   c. What if you couldn't go down yourself? How would you know what was down there? *(Scientists use scuba gear, go down in small submarines, and they send down remotely operated vehicles that contain cameras and collecting gear.)*
   d. At what depth can you find the most canyon species?
   e. Explain that some species can move between depths, like krill and fish, while others are found stationary at different depths. See if they can predict which species are stationary and which travel to different depths.

Journal Prompt Closing Activity

Have students look at the Monterey Submarine Canyon poster and compare animals at the bottom of the canyon to the ones living close to the surface. What similarities and differences do they see between animals at different depths? Are they different sizes, colors, or with bigger eyes? These are examples of adaptations for different environments. Discuss the differences in shallow and deep sea environments and how the adaptations might help organisms survive.

Activity Extensions

If you have access to the internet, visit www.learningdemo.com/noaa to view a video on plate tectonics. Also check the SIMoN website and look at pictures and a flythrough of the Monterey Canyon: http://www.mbnmssimon.org/sections/submarineCanyons/maps_graphs.

Modeling the Canyon Worksheet

LESSON 1.4

Instructions

Label your model canyon depths:

1. Use the topographic map of the canyon and a centimeter ruler to label the canyon depths on the side of your container. Put a piece of tape on the side of the container, so you can write the depths on it.
   Hint: Depending on the depth of your container, you will need to show a scale to label the model.
   For example:
   0.2 centimeters = 200 meters (this will be the shallowest part of our canyon)
   0.5 centimeters = 500 meters
   1 centimeters = 1,000 meters
   1.5 centimeters = 1,500 meters
   2 centimeters = 2,000 meters
   2.5 centimeters = 2,500 meters
   3 centimeters = 3,000 meters (this will be the deepest part of our canyon)
2. Start by labeling the deepest part, the bottom of the canyon, which is about 3,000 meters. Then, continue to label your container every 500 meters moving upwards (2,500 meters, 2,000 metres, etc), and stop at the 500 meter mark.
3. Then label the 200 meters mark, which is the rim of the canyon and the shallowest part.

Modeling your canyon:

1. Using clay and the topographic map, begin to make the canyon.
2. Copy the shape of the canyon and match the depths on the map with the marks on your container.

Labeling your canyon species:

1. Using tape, toothpicks, scissors, paper, and a pen make flags with the species names.
2. Look at the poster of the Grand Canyon of Monterey Bay to see the species names. Choose 10 species.
3. Cut 10 small pieces of paper and write each speciesí name on them, then wrap tape around the paper and the toothpicks, like a flag.
4. Before putting the species flags in the canyon model, you will have to fill in the table below to know where to put each species.
5. Now, look at the Grand Canyon of Monterey Bay poster to find out at what depth each species lives in and place your flag at the right depth in your model.

Unit Conversations

200 meters=	656 feet=	centimeters
500 meters=	1,640 feet=	centimeters
1,000 meters=	3,281 feet=	centimeters
1,500 meters=	4,921 feet=	centimeters
2,000 meters=	6,562 feet=	centimeters
2,500 meters=	8,202 feet=	centimeters
3,000 meters=	10,000 feet=	centimeters

Modelando el Cañón Worksheet

Instrucciones

Marca tu modelo con la profundidad del cañón:

1. Usa el mapa topográfico del cañón y una regla de centímetros para marcar las profundidades en un lado de tu contenedor. Pega un pedazo de cinta adhesiva en un lado de tu contenedor y escribe las profundidades en la cinta. **Consejo:** Necesitas hacer una escala para marcar el modelo según el tamaño de tu contenedor.
   Por ejemplo:
   0.2 centímetros = 200 metros (esta va a ser la parte menos profunda del cañón)
   0.5 centímetros = 500 metros
   1 centímetros = 1,000 metros
   1.5 centímetros = 1,500 metros
   2 centímetros = 2,000 metros
   2.5 centímetros = 2,500 metros
   3 centímetros = 3,000 metros (esta va a ser la parte más profunda del cañón).
2. Empieza por marcar la parte mas profunda del cañón qué es como de 3,000 metros en la parte de debajo de tu contenedor. Después sigue marcando tu contenedor hacia arriba cada 500 metros (2,500 metros, 2,000 metros, etc) y para en la marca de 500 metros.
3. Luego marca la parte menos profunda del cañón que es como de 200 metros.

Moldeando tu cañón:

1. Usando plastilina y el mapa topográfico, empieza a crear tu cañón.
2. Copiar la forma del cañón y sigue las profundidades del mapa para que estén en el mismo lugar de las marcas en tu contenedor.

Marca las especias de tu cañón:

1. Usando cinta, palillos de dientes, tijeras, papel, y una pluma, haz banderitas con los nombres de las especies.
2. Mira tu póster del Gran Cañón de la Bahía de Monterey para ver los nombres de las especies.
   Escoge 10 especies.
3. Corta 10 pedazos pequeños de papel y escribe el nombre de cada especie, luego enrolla el papel con la cinta adhesiva y los palillos de dientes, como una bandera, creando banderitas de especies.
4. Antes de poner las banderas en el modelo del cañón, tienes que llenar la tabla de abajo para que sepas donde poner las especies.
5. Ahora usa el póster del Gran Cañón de la Bahía de Monterey y busca a qué profundidad vive cada especies.

Coloca tus banderitas de especies en las profundidades correctas de tu modelo.

Conversiones Unidades de Medida

200 metros	= 656 pies	=	centímetros
500 metros	= 1,640 pies	=	centímetros
1,000 metros	= 3,281 pies	=	centímetros
1,500 metros	= 4,921 pies	=	centímetros
2,000 metros	= 6,562 pies	=	centímetros
2,500 metros	= 8,202 pies	=	centímetros
3,000 metros	= 10,000 pies	=	centímetros

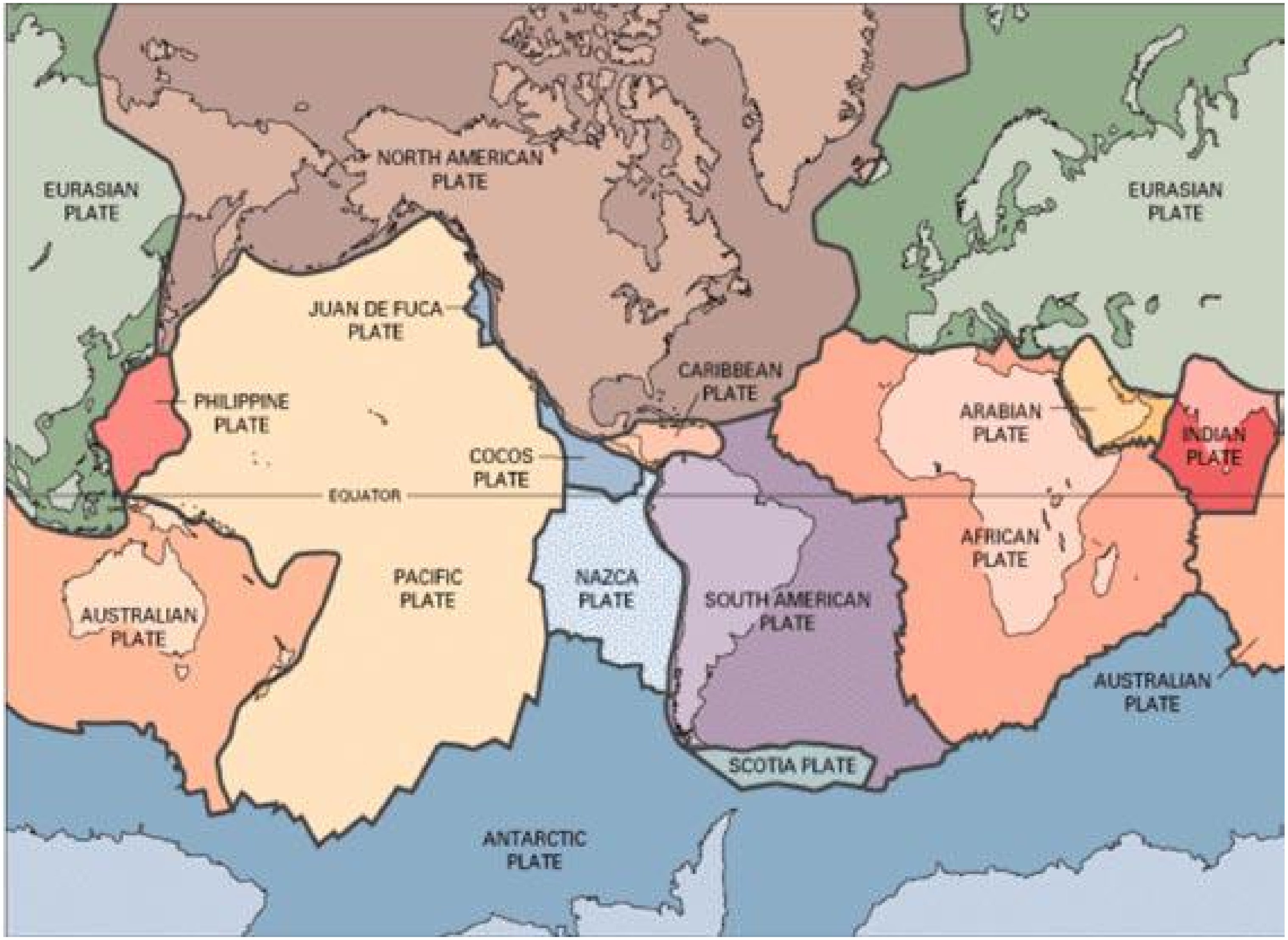


Figure 1.4.1: Tectonic plates of the earth. The surface of the earth is broken into seven big plates and five small ones.
Figure courtesy of US Geological Survey

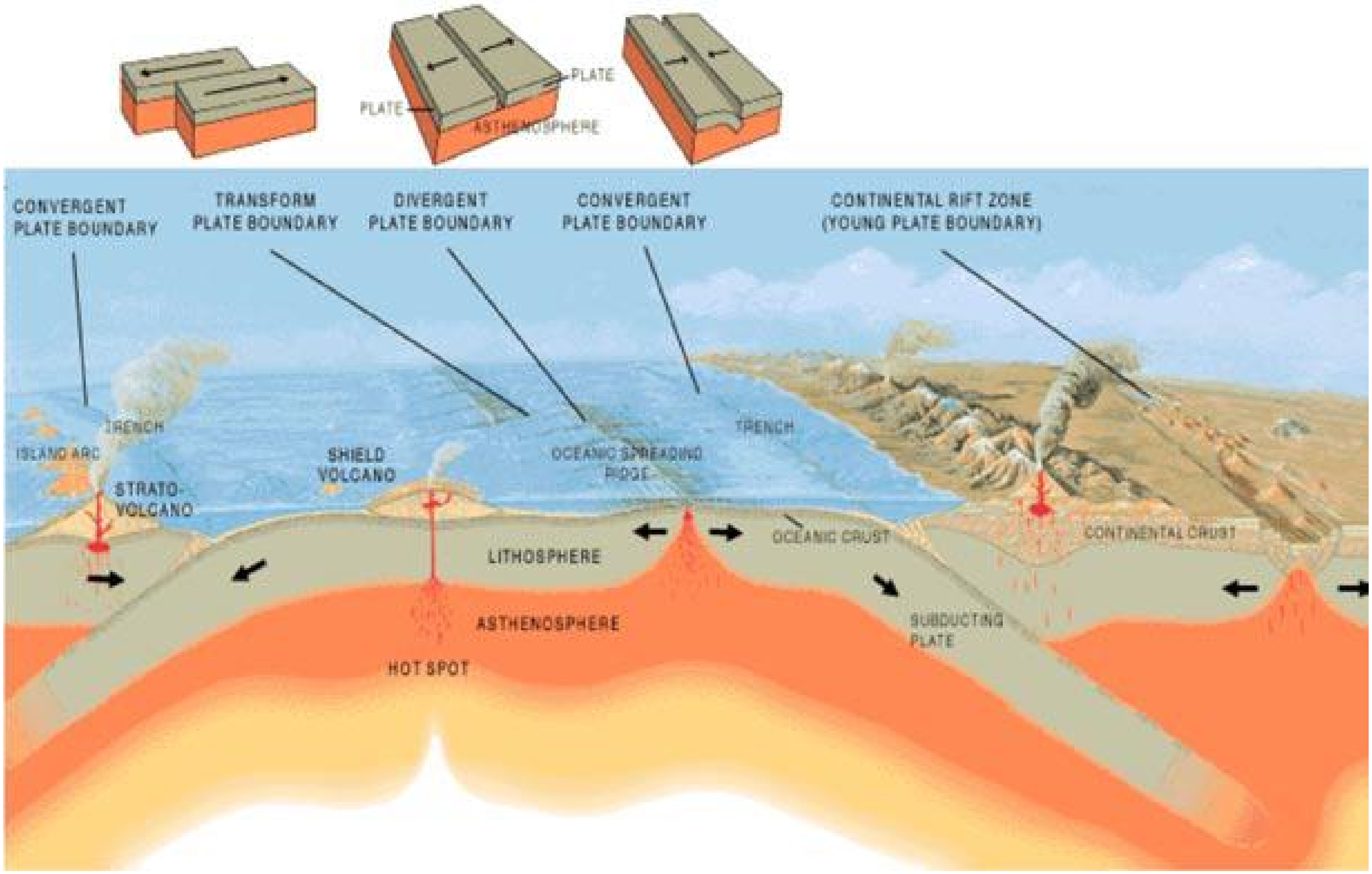


Figure 1.4.2: San Andreas Fault
Figure courtesy of US Geological Survey

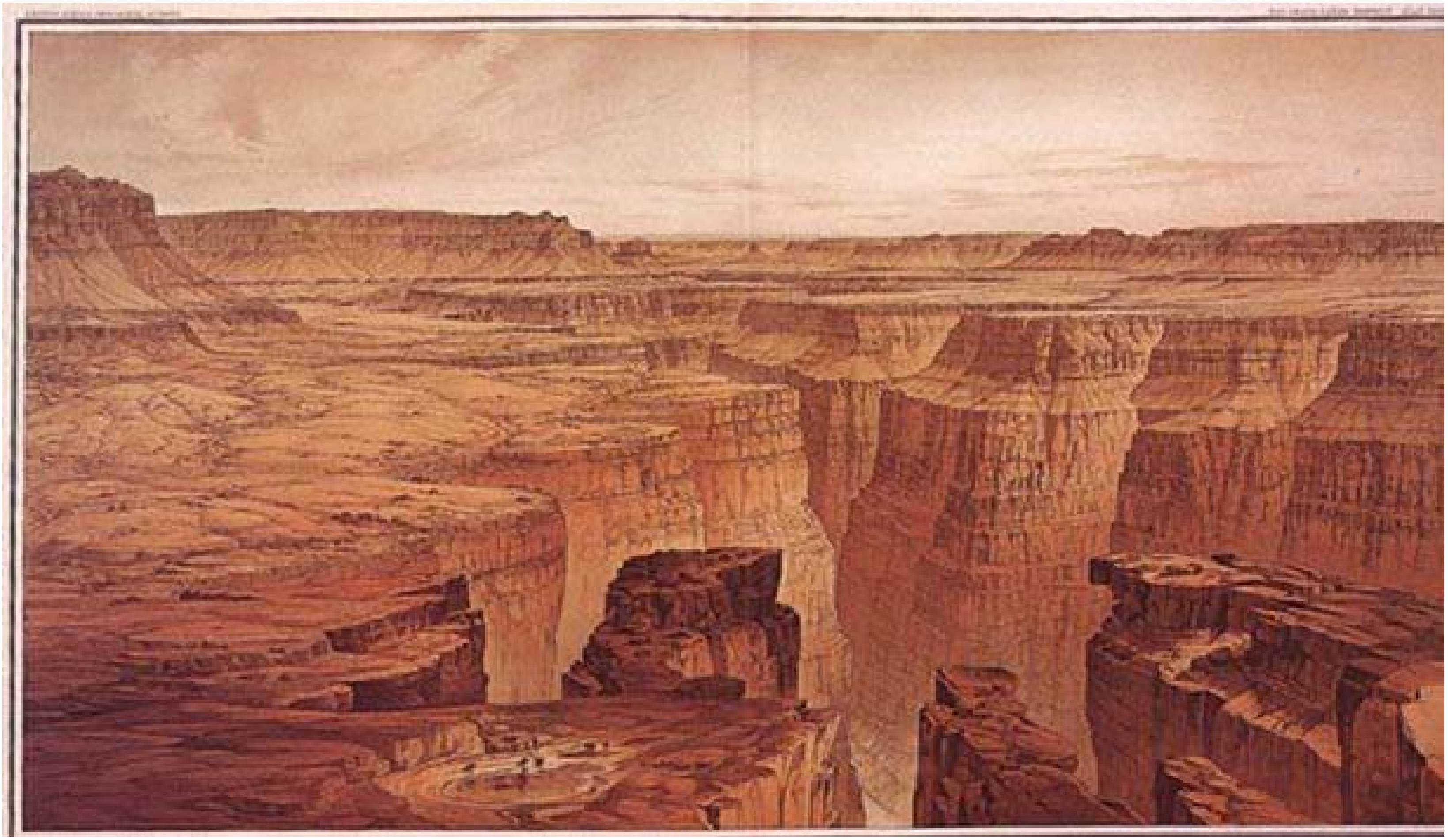


Figure 1.4.3: Overview of the Grand Canyon
Figure courtesy of US Geological Survey

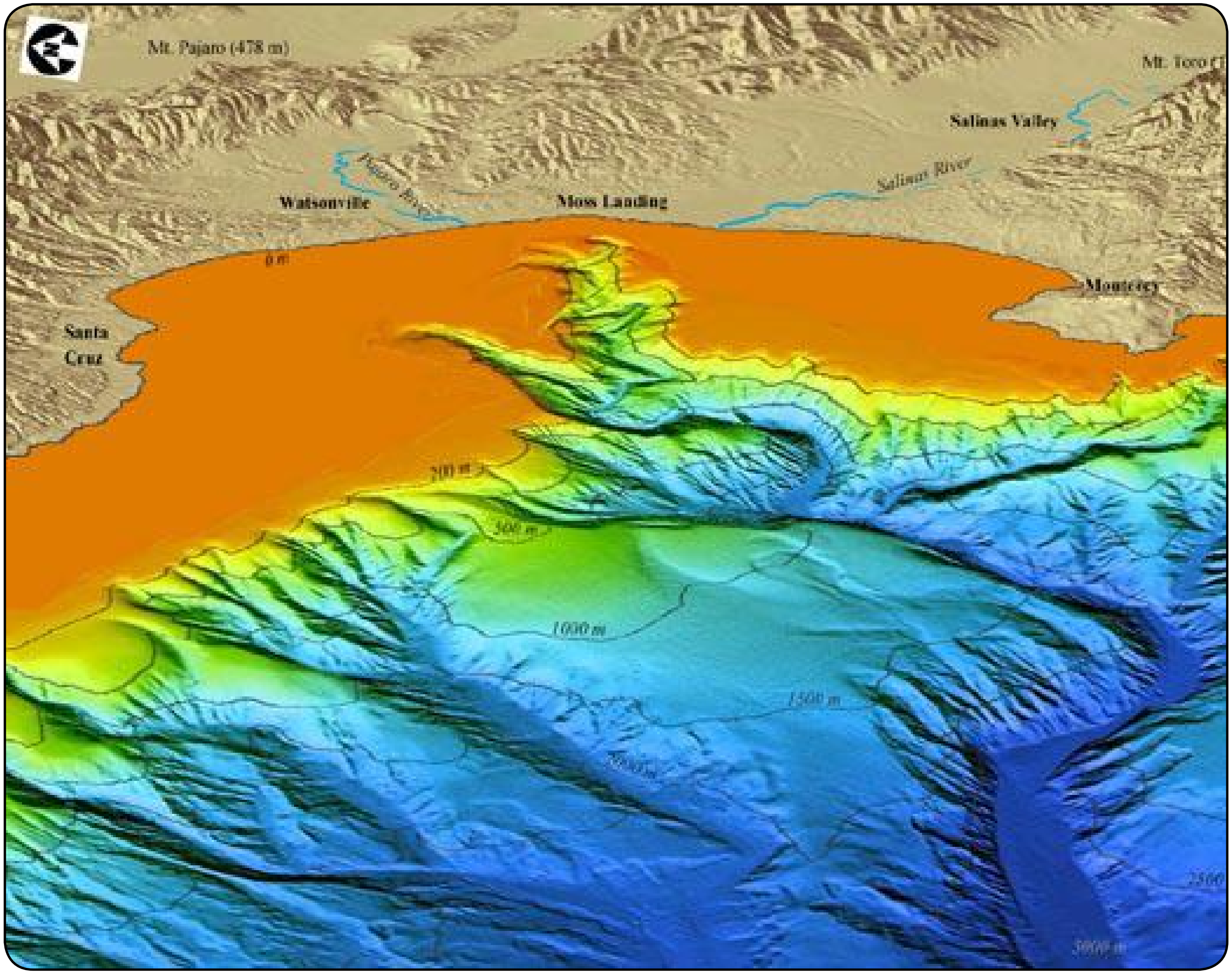


Figure 1.4.4: Overview of the Monterey Canyon
Figure courtesy of US Geological Survey

Visiting the Monterey Bay Aquarium

LESSON 1.5

Summary

Students take a field trip to the Monterey Bay Aquarium. They learn natural history information about ocean communities and habitats, adaptations, and things they can do to help conserve and protect marine resources. An optional worksheet is provided.

Learning Objectives

Students will be able to:

- Name some of the plants, algae, and habitats in the Monterey Bay National Marine Sanctuary
- Name some plants and animals of the Monterey Bay National Marine Sanctuary
- Learn the concept of stewardship and actions they can take on land to protect the Sanctuary

Background

The Monterey Bay Aquarium is one of the premier aquariums in the world, and it's only a one-half hour drive from Watsonville and Salinas. Zoos, aquariums, and many science and nature centers provide people with an opportunity to learn about ecosystems, communities and habitats, and the organisms living in them. The aquarium provides a place to learn about the plants and animals in the Monterey Bay National Marine Sanctuary and the habitats in which they live. The aquarium also promotes stewardship for the organisms living in the ocean.

To prepare your class and your chaperones for the field trip, look at a map of the Aquarium. A sample student worksheet is provided. If you have your students fill out the worksheet while on their field trip, help them get the most out of it by preparing them in advance for what to look for and the kinds of things they might write down. You may also want to photocopy the map on the back of the worksheet so students can navigate better. You may decide to have your class move through the center as a group, or stay in small groups with a chaperone.

Duration

1-3 hours plus travel time

Teacher Prep

1. Contact the Sanctuary's MERITO staff (831-647-4211) with your top preferred field trip dates, number of students and chaperones (one for every 7 students), time and method of arrival and mailing address so they can book your school group through their partnership with the aquarium. If you are interested in having an aquarium staff member greet your class please make sure to notify MERITO staff when scheduling your field trip.

2. Once the field trip has been arranged, you will receive a Monterey Bay Aquarium Planning Guide with your Free-to-Learn group confirmation and a Behavior Contract that you will need to show to the aquarium in order to get in.

3.Copy Field Trip to the Monterey Bay Aquarium worksheets.

4.The Monterey Bay Aquarium's Teacher's Place web page has all you need to know: http://www.mbayaq.org/lc/. The web site has an extensive array of online interactive activities as well as lessons you can download and print for your students.

Visiting the Monterey Bay Aquarium

(Teacher Prep Con't.)
Each activity includes the California content standards addressed. This web site is an incredible resource for local teachers to help students become more familiar with what is around them and underwater. Be sure to use this fantastic local resource often!

Materials

- MBA Planning Guide: Free-to-Learn group confirmation and a signed Behavior Contract
- Visit the aquarium's website at http://www.mbayaq.org/
- Student Worksheet, Monterey Bay Aquarium Field Trip (one is provided or develop your own). You could also have students bring their journals and have them write about their experience at the aquarium
- Pencils

Vocabulary

Monterey Bay Aquarium
Monterey Bay National Marine Sanctuary
Habitats
Stewardship

Activity Procedure

1. Before visiting the aquarium, prepare students by familiarizing them with ocean habitats, (see Lesson 1.1) adaptations of various animals and the physical conditions of the ocean habitats in which they live (See Lessons 2.1 and 2.2).
2. Hand out Field Trip to the Monterey Bay Aquarium worksheets and help students prepare for the field trip by reviewing the questions (optional).
3. Following the field trip, go over the answers on students worksheets and ask them what they learned.

Field Trip to the Monterey Bay Aquarium

Paseo al Acuario de la Bahía de Monterey

Name /Nombre________________

What do sea otters eat?
¿Que comen las nutrias marinas?

How do sea otters stay warm in cold ocean water?
¿Como se mantienen calientes las nutrias en el mar?

Write the names of at least 3 fish you saw. Look at the pictures under the exhibits to get the correct spelling of their names.
Escribe 3 nombres de peces que viste. Mira las fotos de las exposición para ver como se escriben los nombres.

Name at least 3 communities or habitats in the ocean that you learned about.
Escribe 3 comunidades o hábitates del mar que aprendiste.

Draw a picture of one organism you observed. Describe what it was doing.
Dibuja un organismo que viste. Describe que estaba haciendo.

Did you touch any animals? What were they? If not, why?
¿Tocaste algunos animales?¿Cuales? ¿Si no, porque no?

What kinds of things can people (you) do to help protect and conserve the ocean?
¿Qué puede la gente (tú) hacer para proteger y conservar el mar?

What was your favorite exhibit? Why?
¿Cual fue tu exposición preferida? ¿Porque?

Name 3 things you learned today at the Aquarium.
Escribe 3 cosas que aprendiste hoy en el Acuario.

Biodiversity BINGO!

Summary

The Monterey Bay National Marine Sanctuary (MBNMS) contains one of the most diverse and productive ecosystems in the world. In this activity, students learn about the importance of biodiversity by watching a 10-minute video. Students play Biodiversity BINGO! to familiarize themselves with sanctuary species, habitats and adaptations.

Learning Objectives

Students will:

- Become familiar with some of the organisms that make the sanctuary one of the most diverse and productive areas in the world
- Learn about the "Seasons of the Sea", including the Davidson Current, upwelling period, and the oceanic period

Background

Biodiversity is defined as the variety of organisms in a particular ecosystem, which includes all the species from the tiniest microbes to the largest whales. Each habitat or community has its own variety of organisms that make up its biodiversity. The central California coast and ocean have tremendous biodiversity, including many species that migrate through seasonally. This is one of the reasons it is protected by one of the largest marine sanctuaries in the world.

The video included with this lesson introduces the viewer to the "Seasons of the Sea." These periods reflect changing conditions in the marine ecosystem, and the organisms most associated with these seasons. The video serves as an introduction to the tremendous biodiversity of sanctuary waters. The species elected for Biodiversity BINGO! reflect a variety of types of organisms from a wide spectrum of habitats and communities. The sheer variety of the species should help students gain an understanding that life is full of variation based upon adaptation.

Duration

Seasons of the Sanctuary video: 10 minutes
Play Biodiversity BINGO!: 30 minutes
Closing Activity: 20 minutes

Teacher Prep

1. Read activity background
2. Set up appropriate equipment for Seasons of the Sanctuary video
3. Photocopy Biodiversity BINGO! game cards or use cards provided in kit
4. Obtain Bingo markers (beans, pennies, etc.) to cover Bingo card squares
5. Pull out selected species cards from the larger species cards deck:

Bat Star
Black Oystercatcher
Black Turban Snail
Blue Rockfish
Blue Whale
Brown Pelican
By-the-Wind Sailor
California Sea Cucumber
California Mussel
Giant Kelp
Gray Whale
Great Egret
Harbor Seal
Humpback Whale
Leatherback Sea Turtle
Leopard Shark
Northern Elephant Seal
Ocean Sunfish
Orca
Purple-Striped Jelly
Sea Lettuce

(con't. on next page)

Biodiversity BINGO!

LESSON 2.1

Teacher Prep
Sooty Shearwater
Southern Sea Otter
Snowy Plover
Steelhead Trout
Turkish Towel
Western Gull
White-Plumed Anemone
White Shark
Yellowfin Tuna

Materials
- Seasons of the Sanctuary video (provided in kit) and appropriate viewing equipment
- Biodiversity BINGO! game cards (provided in kit)
- Markers i.e. beans, rocks, or similar items (about 16 per student)
- Bingo Species Sheet and Species Cards

Vocabulary
Biodiversity
Davidson Current
Ecosystem
Food chain
Oceanic Period
Upwelling

Journal Prompt Closing Activity
Have students select one of the bingo species and write a description of what they learned about it. What is the season most associated with this organism? Have them draw a picture of the organism in its environment.

Activity Procedure
1. Pull out the assigned species from the Sanctuary species card deck. Pass out one Biodiversity BINGO! game card and bingo markers to each student. Explain to students that you will be calling out clues or descriptions of different animal and plant species who live in the Sanctuary or migrate through it. Their job is to guess which species it is and put a marker on it.

2. Read the descriptions of the selected species cards (see materials list) out loud and have students guess which species it is. You can ask prompt questions or give them any other facts that may help them guess. If students have a hard time guessing, give them the answer and ask them to mark their bingo cards.

3. Continue reading the clues one by one until the first person calls BINGO! Allow one to three students to reach “BINGO.” At the end of each round, students may trade bingo cards. Play as many rounds as you like.

Biodiversity BINGO!

By-the-Wind Sailor	Great Egret	Southern Sea Otter	Black Turban Snail	Sooty Shearwater
Brown Pelican	Ocean Sunfish	Blue Whale	White-Plumed Anemone	California Sea Cucumber
Humpback Whale	Giant Kelp	Orca	Blue Rockfish	Sea Lettuce
California Mussel	Yellowfin Tuna	Leatherback Sea Turtle	Harbor Seal	Purple-Striped Jelly
Turkish Towel	Western Gull	Bat Star	Snowy Plover	Black Oyster-catcher

Biodiversity BINGO!

Great Egret	Snowy Plover	Steelhead Trout	Giant Kelp	Turkish Towel
California Sea Cucumber	California Mussel	Brown Pelican	Sooty Shearwater	White-Plumed Anemone
Sea Lettuce	Purple-Striped Jelly	Leopard Shark	By-the-Wind Sailor	Northern Elephant Seal
Western Gull	Southern Sea Otter	White Shark	Gray Whale	Harbor Seal
Blue Whale	Ocean Sunfish	Leatherback Sea Turtle	Orca	Humpback Whale

Biodiversity BINGO!

Leopard Shark	Orca	Great Egret	Leatherback Sea Turtle	Blue Whale
Harbor Seal	California Sea Cucumber	Gray Whale	California Mussel	Brown Pelican
Humpback Whale	Southern Sea Otter	Sooty Shearwater	By-the-Wind Sailor	Northern Elephant Seal
Purple-Striped Jelly	Western Gull	White Shark	White-Plumed Anemone	Snowy Plover
Ocean Sunfish	Giant Kelp	Steelhead Trout	Turkish Towel	Sea Lettuce

Biodiversity BINGO!

Bat Star	Yellowfin Tuna	Orca	California Mussel	Sooty Shearwater
Leopard Shark	Black Oyster-catcher	Sea Lettuce	Snowy Plover	Northern Elephant Seal
Gray Whale	Blue Whale	Humpback Whale	Blue Rockfish	Ocean Sunfish
California Sea Cucumber	Leatherback Sea Turtle	Harbor Seal	Great Egret	By-the-Wind Sailor
Black Turban Snail	Brown Pelican	Giant Kelp	Southern Sea Otter	Purple-Striped Jelly

Biodiversity BINGO!

California Mussel	By-the-Wind Sailor	Gray Whale	White Shark	Humpback Whale
Sooty Shearwater	Leatherback Sea Turtle	White-Plumed Anemone	Sea Lettuce	Southern Sea Otter
Ocean Sunfish	Leopard Shark	Brown Pelican	California Sea Cucumber	Purple-Striped Jelly
Northern Elephant Seal	Snowy Plover	Giant Kelp	Turkish Towel	Great Egret
Western Gull	Orca	Steelhead Trout	Blue Whale	Harbor Seal

Biodiversity BINGO!

Southern Sea Otter	Leopard Shark	Harbor Seal	Ocean Sunfish	By-the-Wind Sailor
Giant Kelp	Gray Whale	Great Egret	Brown Pelican	Leatherback Sea Turtle
Orca	Bat Star	Northern Elephant Seal	California Mussel	Blue Rockfish
California Sea Cucumber	Sea Lettuce	Yellowfin Tuna	Black Oystercatcher	Sooty Shearwater
Purple-Striped Jelly	Black Turban Snail	Blue Whale	Humpback Whale	Snowy Plover

Biodiversity BINGO!

Turkish Towel	Brown Pelican	Southern Sea Otter	Harbor Seal	California Mussel
Orca	Great Egret	Leopard Shark	Western Gull	White-Plumed Anemone
Purple-Striped Jelly	By-the-Wind Sailor	Steelhead Trout	Snowy Plover	Humpback Whale
Giant Kelp	Northern Elephant Seal	Sea Lettuce	Leatherback Sea Turtle	Blue Whale
Ocean Sunfish	Gray Whale	California Sea Cucumber	Sooty Shearwater	White Shark

Biodiversity BINGO!

Turkish Towel	White-Plumed Anemone	Sea Lettuce	By-the-Wind Sailor	Snowy Plover
Western Gull	Harbor Seal	Ocean Sunfish	Orca	Leatherback Sea Turtle
Northern Elephant Seal	California Sea Cucumber	Blue Whale	Giant Kelp	Humpback Whale
California Mussel	Gray Whale	Steelhead Trout	Brown Pelican	Southern Sea Otter
Sooty Shearwater	Leopard Shark	Purple-Striped Jelly	Great Egret	White Shark

Biodiversity BINGO!

Ocean Sunfish	Orca	Gray Whale	Purple-Striped Jelly	Harbor Seal
Brown Pelican	Giant Kelp	Southern Sea Otter	Yellowfin Tuna	Bat Star
Northern Elephant Seal	Leatherback Sea Turtle	Great Egret	California Mussel	By-the-Wind Sailor
Sooty Shearwater	Snowy Plover	Leopard Shark	California Sea Cucumber	Blue Rockfish
Black Turban Snail	Blue Whale	Humpback Whale	Sea Lettuce	Black Oyster-catcher

Biodiversity BINGO!

Blue Whale	Turkish Towel	Western Gull	Leopard Shark	Leatherback Sea Turtle
California Sea Cucumber	White Shark	Sea Lettuce	Northern Elephant Seal	Purple-Striped Jelly
Steelhead Trout	Sooty Shearwater	Humpback Whale	Southern Sea Otter	California Mussel
By-the-Wind Sailor	Harbor Seal	Snowy Plover	Great Egret	Orca
Ocean Sunfish	Brown Pelican	Gray Whale	White-Plumed Anemone	Giant Kelp

Biodiversity BINGO!

Southern Sea Otter	Black Oyster-catcher	California Sea Cucumber	Great Egret	Gray Whale
Black Turban Snail	Giant Kelp	Bat Star	Brown Pelican	Sooty Shearwater
Leatherback Sea Turtle	California Mussel	By-the-Wind Sailor	Sea Lettuce	Northern Elephant Seal
Blue Whale	Harbor Seal	Ocean Sunfish	Snowy Plover	Yellowfin Tuna
Leopard Shark	Humpback Whale	Blue Rockfish	Orca	Purple-Striped Jelly

Biodiversity BINGO!

Sea Lettuce	Sooty Shearwater	Humpback Whale	Brown Pelican	Northern Elephant Seal
Steelhead Trout	Gray Whale	Ocean Sunfish	Orca	Turkish Towel
Purple-Striped Jelly	Great Egret	White Shark	California Mussel	Harbor Seal
By-the-Wind Sailor	Leopard Shark	Blue Whale	Western Gull	Snowy Plover
Giant Kelp	Leatherback Sea Turtle	Southern Sea Otter	California Sea Cucumber	White-Plumed Anemone

Biodiversity BINGO!

Purple-Striped Jelly	Western Gull	Brown Pelican	White-Plumed Anemone	Leopard Shark
Southern Sea Otter	Harbor Seal	Gray Whale	Great Egret	Blue Whale
Humpback Whale	Leatherback Sea Turtle	Snowy Plover	Steelhead Trout	Ocean Sunfish
Sooty Shearwater	White Shark	By-the-Wind Sailor	Northern Elephant Seal	California Mussel
Orca	Giant Kelp	Sea Lettuce	California Sea Cucumber	Turkish Towel

Biodiversity BINGO!

Black Turban Snail	Humpback Whale	Harbor Seal	Leatherback Sea Turtle	Ocean Sunfish
Yellowfin Tuna	Gray Whale	Sooty Shearwater	California Sea Cucumber	California Mussel
Brown Pelican	Purple-Striped Jelly	Sea Lettuce	Black Oystercatcher	Northern Elephant Seal
Great Egret	Snowy Plover	Blue Whale	By-the-Wind Sailor	Southern Sea Otter
Leopard Shark	Blue Rockfish	Orca	Giant Kelp	Bat Star

Biodiversity BINGO!

Leopard Shark	Humpback Whale	Giant Kelp	Snowy Plover	By-the-Wind Sailor
Brown Pelican	Northern Elephant Seal	Western Gull	California Mussel	Ocean Sunfish
California Sea Cucumber	Steelhead Trout	Sooty Shearwater	Sea Lettuce	Great Egret
Purple-Striped Jelly	White-Plumed Anemone	Turkish Towel	Leatherback Sea Turtle	Southern Sea Otter
Harbor Seal	Blue Whale	Orca	White Shark	Gray Whale

Biodiversity BINGO!

Humpback Whale	Yellowfin Tuna	By-the-Wind Sailor	Brown Pelican	Giant Kelp
Harbor Seal	Great Egret	Orca	Bat Star	Sooty Shearwater
Southern Sea Otter	California Sea Cucumber	Northern Elephant Seal	Purple-Striped Jelly	Blue Whale
Black Turban Snail	Leatherback Sea Turtle	Ocean Sunfish	Leopard Shark	California Mussel
Gray Whale	Blue Rockfish	Sea Lettuce	Black Oystercatcher	Snowy Plover

Biodiversity BINGO!

Gray Whale	California Mussel	Blue Whale	Orca	Leopard Shark
Purple-Striped Jelly	Western Gull	Turkish Towel	White-Plumed Anemone	Harbor Seal
California Sea Cucumber	White Shark	Snowy Plover	Brown Pelican	Ocean Sunfish
Great Egret	Sooty Shearwater	Northern Elephant Seal	Steelhead Trout	Leatherback Sea Turtle
Humpback Whale	Sea Lettuce	Giant Kelp	Southern Sea Otter	By-the-Wind Sailor

Biodiversity BINGO!

California Sea Cucumber	Sea Lettuce	Great Egret	Black Oystercatcher	Ocean Sunfish
Humpback Whale	Leopard Shark	Northern Elephant Seal	Yellowfin Tuna	Leatherback Sea Turtle
Black Turban Snail	Blue Rockfish	Giant Kelp	Sooty Shearwater	California Mussel
Harbor Seal	Bat Star	Orca	Brown Pelican	Purple-Striped Jelly
By-the-Wind Sailor	Snowy Plover	Southern Sea Otter	Blue Whale	Gray Whale

Biodiversity BINGO!

Black Oyster-catcher	California Sea Cucumber	Great Egret	Black Turban Snail	Harbor Seal
Leopard Shark	Brown Pelican	Giant Kelp	Southern Sea Otter	Humpback Whale
Sea Lettuce	Bat Star	Orca	Purple-Striped Jelly	By-the-Wind Sailor
Ocean Sunfish	Gray Whale	Blue Rockfish	Northern Elephant Seal	California Mussel
Yellowfin Tuna	Blue Whale	Sooty Shearwater	Snowy Plover	Leatherback Sea Turtle

Biodiversity BINGO!

Bat Star	Black Oyster-catcher	Harbor Seal	Giant Kelp	Southern Sea Otter
Yellowfin Tuna	Humpback Whale	By-the-Wind Sailor	Northern Elephant Seal	Great Egret
Brown Pelican	Blue Whale	Ocean Sunfish	Leopard Shark	Blue Rockfish
Sooty Shearwater	Black Turban Snail	California Mussel	Orca	Purple-Striped Jelly
Sea Lettuce	Gray Whale	Snowy Plover	Leatherback Sea Turtle	California Sea Cucumber

Adaptation Stations

LESSON 2.2

Summary

In this activity, students work in groups visiting Adaptation Stations to determine if their species have adaptations similar to the tools at the station. Students write similes to relate each species to the adaptation and its function (e.g. a crab uses its pinchers like tongs to pick up food). Each student shares one of their worksheet species' adaptations. Teacher and peers confirm all appropriate adaptations have been identified and brainstorm additional possibilities. As an extension, students may choose one species and write a story about how its adaptations help it survive, and how humans affect its environment.

Learning Objectives

Students will be able to:

- Define the term adaptation
- Explain how adaptations help animals and plants to survive in their habitats
- Identify adaptations of three animals in the Sanctuary

Background

Adaptations are structures or behaviors that help a living thing survive in its environment. Plants and animals have structural adaptations that serve different functions. Humans have fingers for picking up things they need. Birds have wings that allow them to fly to find food or to fly away from predators. Crabs have claws that help them to defend themselves and to pick up food. Male seahorses have pockets on their bodies to protect their offspring. Plants have stems that transport water upward, against gravity from their roots to their leaves.

Plants and animals also exhibit behavioral adaptations. A behavioral adaptation is something that a living thing does to help it avoid injury or death. Humans blink if something passes near their eye. Turtles pull their head, arms and legs inside their shell for protection. Plants bend towards sunlight to capture energy from the sun, or drop leaves when they lack water.

Camouflage is an adaptation that helps a living thing blend in with its surroundings. When organisms change their behavior, shape, color, and/or pattern, it is harder for predators and prey to see them. Octopuses and flatfishes are able to change the color of their bodies to match their environment. Pipefish are long, slender fishes that live among eelgrass. The blades of eelgrass, also long and slender, sway back and forth with the movement of the water. Pipefish orient their bodies to blend with the swaying eelgrass. This behavior camouflages the pipefish from its predators and its prey.

Duration

Introduction to Adaptations: 15 minutes
Adaptations Stations: 30-45 minutes
Closing Activity: 15 minutes

Teacher Prep

1. Read activity background
2. Gather tools, refer to Tool List and Species' Adaptations table
3. Photocopy Adaptations Similes worksheet (double sided), one per student
4. Arrange Adaptations Stations: 4-5 tool stations around the room, divide tools equally in each station
5. Pull out the selected species cards from the larger species card deck (see Materials)

Materials

- Tools/objects from Tool List and Species' Adaptations table
- Adaptation Similes worksheet
- Pencils
- Bell or timer
- Selected species cards:

Black Oystercatcher
Blue Rockfish
Brown Pelican
Deep-Sea Anglerfish
Giant Green Anemone
Giant Pacific Octopus
Great Egret
Harbor Seal
Humpback Whale
Leatherback Sea Turtle
Leopard Shark
Marbled Godwit
Northern Elephant Seal
(cont. on next page)

Adaptation Stations

Orca
Pacific Sanddab
Purple Shore Crab
Purple Striped Jelly
Sand Crab
Southern Sea Otter
Sunflower Star
White-Plumed Anemone
White Shark

Vocabulary

Adaptation
  Behavioral
  Structural
Camouflage
Simile

Activity Extensions

1. Students choose one species and write a story describing its habitat and how adaptations help it survive.
2. Human Impact Activity: Explain to students that some adaptations won't work if they are impaired by things that we do or objects we use on land that enter the ocean through watersheds and rivers. Place a rubber band around the tongs to represent the crab getting its claws caught in a six-pack ring, or put oil on the fake fur to simulate oil pollution in the water. Write on the board the list of marine debris from the Marine Debris Fact Sheet, and have students brainstorm how these items could affect the different types of life in the sea.

Similes are word comparisons that show how two different things are similar in one important way. Similes use the words "as" or "like" to make the connection between the two things being compared. Comparing an unfamiliar animal or plant adaptation to something that students are familiar with helps to build understanding. Consider the following similes:

The simile: The shell of a turtle is **as hard as** a helmet.
The explanation by linking the unfamiliar with the familiar: The shell of a turtle and a helmet both protect sensitive body parts.

The simile: Shark teeth are **like** knives.
The explanation by linking the unfamiliar with the familiar: White shark teeth and knives are both used to cut things like meat.

The simile: A sea otter's fur is **like** a heavy jacket.
The explanation by linking the unfamiliar with the familiar: Sea otter fur and heavy jackets are both used for warmth.

Activity Procedure

Introduction to Adaptations

1. Hand out a rubber band to each student and tell them to put the rubber band around their thumb and first finger so they can't be separated. Show them how to do it on your own hand (don't make it so tight as to cut off circulation). Now ask them to pick up a pencil, or a book, or to tie their shoe. It is almost impossible to do this without a thumb! Humans are one of the few species that have opposable thumbs (that is, thumbs that are aligned opposite from fingers, so that we can touch the tips of our thumbs to our fingers). We share this adaptation with a few other mammals, including pandas, koalas, opossums, orangutans, and several primates in Central and South America. Many tasks in our life depend on our ability to rotate our thumb and have it be fully opposable to the tips of our other fingers. Our ability to survive and function is better because we have opposable thumbs.

2. Write the word **Adaptation** on the board. Explain that adaptations are structures or behaviors that help a living thing survive in its environment. Some adaptations are structural – like the opposable thumb. Other adaptations are behavioral, like hiding from a predator.

3. Discuss other kinds of adaptations with your students. For example, sweating on a hot day cools the body, and putting on a jacket on a cold day warms the body. Sweating is a structural adaptation (our body does it automatically). Putting on a jacket is a behavioral adaptation – it requires thought and effort.

Adaptation Stations

Adaptations Stations

1. In this activity, students move from station to station, observing tools that represent adaptations used by other organisms. The tools show the similarities between different kinds of adaptations. Students will then write sentences using word similes, comparing the tools to animal adaptations. A simile compares two different things using the word "like" or "as." Write some examples of similes on the board such as, "These tongs are like a crab's claws. Crabs use their claws to pinch things." "The sea otter has fur that works *like* a coat to keep it warm."

2. Explain to students that the tools are similar to adaptations different organisms have to help them survive. The organisms are represented by the cards from the Sanctuary Species deck. Students are to visit each adaptation station and figure out which "tools" are used by which animals, then fill in their worksheets using similes. Use examples from the Tool List and Species' Adaptations table included with this lesson.

3. Divide students into groups of 4 or 5 (depending on the number of students and stations you have).

4. Divide the selected Sanctuary Species Cards into equal amounts (depending on the number of groups you have) and hand out a stack to each group. Hand out an Adaptation Similes worksheet and a pencil to each student.

5. Start each group at a different station and start timing. Give groups five to seven minutes at each station (for the first station see if this is enough time for them to investigate and complete their similes; if not, have them stay at the stations for a few more minutes). Students may talk in their groups to discuss how the tools on the table compare to the animals' body parts of each species card. The same tool may be *used by different species in different ways!*

6. After five minutes, ring the bell or timer and tell students to move to the next station. Once the groups have rotated through all the stations, have them trade their stack of cards with another group.

7. The activity is finished when students have rotated through all the adaptation stations with each stack of cards.

Journal Prompt Closing Activity

Have each student select one simile from his/her worksheet and read it to the class. Use a class discussion to talk about the similes and which ones were most effective. If there is time, have students draw a picture of the simile they read aloud. For example, using the simile "A stingray uses his tail like a person uses a sword," draw a picture of a stingray and a sword, showing how the two are similar in shape and size.

Tool List and Species' Adaptations

LESSON 2.2

Tools/Objects	Species body parts	Function
Tongs Chopsticks	Crab pinchers Brown Pelican beak Black Oystercatcher beak Great Egret beak	To catch and hold prey
Swim fins	Southern Sea Otter flippers Leopard Shark fins and tail Blue Rockfish fins and tail Pacific Sanddab fins and tail Deep Sea Anglerfish fins and tail White Shark fins and tail Harbor Seal flippers Elephant Seal flippers Leatherback Sea Turtle flippers Whale fins and tail	To swim and move around
Knife (plastic) Pasta cutter	Harbor Seal teeth Southern Sea Otter teeth Orca teeth	To cut and chew through meat
Helmet	Lined Shore Crab shell Leatherback Sea Turtle shell Sand Crab shell	To protect body parts
Suction cup	Sunflower Star tube feet White-Plumed Anemone foot Giant Pacific Octopus suction cups Giant Green Anemone foot	To stick to rocks
Strainer	Brown Pelican beak Humpback Whale baleen Deep Sea Anglerfish teeth	To strain water and keep food caught
Straws	Clam siphon	To breathe and eat under the sand or mud
Camouflage cloth	Pacific Sanddab Leopard Shark Blue Rockfish White Shark Giant Green Anemone White-Plumed Anemone	To blend in with its surroundings and hide from predators
Fishing lure (bait)	Deep Sea Anglerfish lure	To catch prey
Heavy jacket	Southern Sea Otter fur Whale skin and blubber Northern Elephant Seal skin and blubber Harbor Seal blubber	To keep warm
Scotch tape	Giant Green Anemone tentacles Purple Striped Jelly tentacles White-Plumed Anemone	To catch food

Adaptation Similes

Símiles de Adaptaciones de Especies

Instructions/ *Instrucciones*:

1. Look at one of your species. What adaptations do you think it has?
   Mira una de tus especies. ¿Qué adaptaciones crees que tenga?

2. Look at a tool on the table. How is this tool like an adaptation for your species?
   Mira una de las herramientas sobre la mesa. ¿Cómo se parece esta herramienta a una adaptación de tu especie?

3. Write the name of your species on the left column.
   Escribe el nombre de tu especie en la columna izquierda.

4. Then write a simile on the right column: compare the tool to your species' adaptations and how is it used.
   Después escribe una símil en la columna derecha: compara la herramienta a las adaptaciones de tu especie y como la usa.

Example / *Ejemplo*:
Species name: Stingray / *Raya*
Simile: A stingray uses its tail like a person uses a sword, to defend itself.
La raya usa su cola como una persona usa una espada, para defenderse.

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Species name: ____________________ Simile: ____

Adaptation Similes

Simile examples

·A crab uses its shell like a person uses a helmet, to protect it from injury.

·A bird uses its beak like people use chopsticks, to catch and hold food.

·A shark uses its tail like people use swim fins, to swim faster.

·A sea otter uses its teeth like people use a knife, to cut and eat meat.

·A sea star uses tube feet to stick to the rocks, like people use a suction cup to stick to glass.

·A harbor seal uses its fur like people use a heavy jacket, to keep warm.

·An anemone's tentacles are like tape, things stick to them!

·The baleen of a gray whale is like a strainer, the food stays in while the water flows out.

·A clam use its siphons to suck in food and air under the mud, like people use a straw to suck a drink out of a cup.

·A blue rockfish uses its skin and scales like people use camouflage cloth, to blend in with its surroundings and hide.

·A deep-sea anglerfish uses its lure like people use a fishing lure, to catch prey.

Marine Debris Fact Sheet

Results of more than 10 years of volunteer beach cleanup data indicate that 60 to 80 percent of beach debris comes from land-based sources. And debris in the marine environment means hazards for animals and humans. Plastic marine debris affects at least 267 species worldwide, including 86 percent of all sea turtle species, 44 percent of all sea bird species, and 43 percent of marine mammal species.

What is marine debris?
Marine debris is any man-made material that enters the ocean by dumping at sea or as runoff from land via rivers, streams, and storm drains. Marine debris can include everything from plastics and metals to toxic contaminants.

How does trash become marine debris?
Look around the next time you walk down the street. When it rains, trash on sidewalks and streets accumulates in the gutter and is swept into your city's storm drain system. Most storm drain systems discharge directly into the nearest waterway, which eventually flows to the ocean. Trash may also be dumped directly into the ocean by recreational and commercial boaters, and is often left on the beach by beach-goers.

How does marine debris affects marine animals?
Marine debris can affect marine life by direct harm, such as drift nets that get caught around the necks of sea lions, or indirect harm, such as birds eating plastic thinking it is food, and starving to death from malnutrition.

How do animals get entangled by marine debris?
Marine animals, like whales, dolphins, turtles, seals, crabs, lobsters, and seabirds become tangled with marine debris impeding their mobility, and ability to eat, breathe or swim which can have fatal consequences.
Examples of entangling debris include:
Rope
Nets
Fishing line
Strapping bands
Six-pack rings

How do animals eat marine debris?
Many marine animals, like birds, fish, sea turtles, whales and other marine mammals often eat floating marine debris, which blocks their intestines and gives them a false sense of being full. They slowly dye of starvation. Birds can also feed marine debris to their young.

Examples of debris animals eat:
Cigarette butts
Styrofoam pallets
Plastic bags
Balloons
Plastic wrappers

Other examples of marine debris:
Appliances
Cigarette lighters
Electronics
Hard hats
Gloves
Food packaging
Beverage containers
Toys
Sewage
Pieces of wood and siding from construction projects
Medical items (i.e., syringes)

How can we help?
- Reduce, reuse, and recycle at home, work and school.
- Buy products made from recycled materials with little or no packaging.
- Keep storm drains clean because they drain to beaches.
- Keep cigarette butts off streets and beaches.
- Properly dispose of fishing lines, nets and hooks.
- Participate in the Monterey Bay National Marine Sanctuary programs (831) 647-4201 and Coastal Commission's programs (800) COAST-4U.

(Modified from California Coastal Commission: check their web site for more information: http://www.coastal.ca.gov)

What's in a Name?

LESSON 2.3

Summary

In this activity, students learn about what scientific classification is based on and organize animals in the Sanctuary according to their type. Students learn about the Latin and Greek roots of scientific areas of study and play Scientist BINGO!

Learning Objectives

Students will be able to:

- Identify three different characteristics used to classify animals
- Know that scientific names of plants and animals are based on Greek and Latin roots, and list three examples
- Describe how a universal naming classification helps us understand biodiversity
- Identify what a species is and the six major groups of animals

Background

The next time you walk into a grocery store, look at how it is organized. Milk and dairy products are placed next to each other. Vegetables and fruits are in the same general area. Beverages are placed in the same aisle, and the check-out stands are all in the same part of the store. Some people shop according to how their store is organized — they shop one section at a time, finding everything they need.

Classification—the arrangement of objects, ideas, or information into groups—makes things easy to find, identify, talk about, and study. In the 1730s Carolus Linneaus proposed a system for naming, ranking, and classifying organisms. His system is still in wide use today, although many modifications have been made. This system proceeds from more inclusive to less inclusive and groups organisms in categories based on their similarities.

In the Animal Kingdom, animals are first grouped according to whether they have a backbone or not. Animals with backbones are called vertebrates, while those without backbones are called invertebrates. Vertebrates are divided into 5 groups: Mammals, Birds, Reptiles, Amphibians, and Fishes. These in turn are organized by certain physical characteristics. The Sanctuary Species Cards describe the characteristics of the animals they represent.

Linnaeus also proposed a system of naming organisms based on the language of study at that time, Latin. Now rarely used in modern society, Latin is still the language of science. All living things have a Latin scientific name that describes aspects of the organism and groups it with similar organisms. Latin forms the roots of many modern languages, including Spanish, English, Italian and French. Some Latin words were borrowed from an even older language, Greek. The game "Scientist BINGO!" helps

Duration

Sanctuary Animal Classification:
30-45 minutes
Scientist BINGO!:
30 minutes
Closing Activity:
15 minutes

Teacher Prep

1. Read activity background
2. Photocopy Classifying Animals worksheet (double-sided), one per student
3. Photocopy Greek and Latin roots handout (in Appendix), one per group
4. Go through the stack of species cards and remove cards that represent the sun, plants, and plankton.
5. Only animal cards will be used. Then, divide cards into 4 stacks.
6. Cut butcher paper into approximately 2' x 2' squares

What's in a Name?

LESSON 2.3

Materials

- Sanctuary species cards (provided in kit). Remove cards that don't describe animals
- Classifying Animals worksheet
- Greek and Latin roots handout (in Appendix)
- Butcher paper and markers
- Scientist BINGO! Cards and Call Sheet
- Bingo Markers (beans, beads, chips, etc)
- Pencils

Vocabulary

Amphibian
Animal Kingdom
Bird
Classification
Carolus Linneaus
Fish
Invertebrate
Latin
Mammal
Reptile
Vertebrate

students learn the Latin and Greek roots for many areas of scientific study while expanding their awareness of careers in science. For more information on marine careers visit Sea-grant's website on marine careers at http://www.marinecareers.net or the Marine Advanced Technology Education Center's website at http://www.oceancareers.com

Activity Procedure

Sanctuary Animal Classification

1. Hand out a *Classifying Animals* worksheet to each student and go over the categories and definitions. Select a few cards from the Sanctuary Species Cards to use as examples. For example: the Gray Whale card describes it on the last line: it has bones and skin with very few fine hairs. It is warm-blooded and gives birth to live young. Reading from the worksheet categories, students should be able to determine that the Gray Whale is a mammal. Explain to students they will be classifying different Sanctuary animal species into the categories on the handout.

2. Break the class into four groups. Hand each group the handout, "Animal Classification Characteristics" and a large piece of butcher paper and pencils. Have the students divide the paper into 5 sections and label the sections "Invertebrates," "Fishes," "Birds," "Mammals," "Reptiles."

3. Give each group a batch of Sanctuary species cards (animals only).

4. Using the information provided in the handouts, tell students to work as a group of scientists to classify their Sanctuary species by placing each picture in the proper section. They can read the description on the back of each card to look for clues on each species characteristics and read the characteristics on the table to see which match up. Students then decide as a group in which section they should place their species.

5. When finished have students write the names of the species in their worksheet under the appropriate column. Teacher Tip: For additional hints, they can look in the Appendix for *Greek and Latin roots* to see what their species names are based upon.

6. Once the groups are done with their first batch of cards, check for understanding by having each group discuss how they classified the animals in their stack of cards. Groups can switch card stacks and repeat the activity as appropriate.

What's in a Name?

Scientist BINGO!

1. Scientists who study the sanctuary and its resources have many different jobs. Each plays an important role in understanding organisms, habitats, communities and ecosystems in the sanctuary. If you wanted to become a sanctuary scientist, there are many different types of jobs you could get–which are named after the organisms or science they study.

2. Hand out the Key to Common Latin Roots, Prefixes, and Suffixes from the Appendix section, or put it on an overhead projector or on the board. The section, Roots of Scientific Areas of Study provides information students can use to help them with the game.

3. Go over the word roots for science professions that are written on the call sheet with your students. You may write all the jobs on the board and explain to students the Latin or Greek word roots (in parentheses below the science profession title, as in Botanist (*botan = of plants*). This section will help students to better understand and guess the scientist quotes that are being called out during the BINGO game. Repeat as often as appropriate.

Journal Prompt Closing Activity

Have students discuss or write about what kind of career in science they might want to have, based upon the option they learned about. Or if students do not want a career in a science field, ask them why not. Have students share their thoughts or journal entries with small groups or with the class.

Animal Classification Characteristics

Características de Animales

LESSON 2.3

Group of Animals *Grupo de Animales*					
Characteristics *Características*	Mammals *Mamíferos*	Fishes *Peces*	Invertebrates *Invertebrados*	Reptiles *Reptiles*	Birds *Pájaros*
Animal with a vertebrate and bones? *¿Animal con columna vertebral y huesos?*	Yes *Sí*	Yes *Sí*	No	Yes *Sí*	Yes *Sí*
Warm-blooded or cold-blooded? *¿De sangre caliente o fría?*	Warm *Caliente*	Cold *Fría*	Cold *Fría*	Cold *Fría*	Warm *Caliente*
Type of body covering *Tipo de cobertura del cuerpo*	Skin, Fur, Hair *Piel, Pelo*	Scales *Escamas*	No Skin, Fur, Hair, or Scales *Sin Piel, Pelo, o Escamas*	Scales *Escamas*	Feathers Plumas
Live birth or hatched from egg? *Da a luz crías vivas o pone huevos?*	Live Birth *Da a luz crías vivas*	Both *Las dos cosas*	From Eggs *Pone huevos*	From Eggs *Pone huevos*	From Eggs *Pone huevos*
Young (babies) are fed milk? *¿Se alimentan de leche las crías?*	Yes *Sí*	No	No	No	No
Breathes with lungs or gills? *¿Respiran con pulmones o agallas?*	Lungs *Pulmones*	Gills *Agallas*	Both *Las dos cosas*	Lungs *Pulmones*	Lungs *Pulmones*

Animal Classification Characteristics

Características de Animales

LESSON 2.3

- **Invertebrates:** Includes all animals without backbones. Invertebrates are cold-blooded (except some groups of insects, including bumblebees). They do not have fur, hair, or scales, they almost always lay eggs, and they can have up to 8 appendages (body parts such as arms, legs, tail, flukes or flippers). Some invertebrates live in water, some live on land and some can live in both environments.

- ***Invertebrados:*** *Incluye todos los animales sin columnas vertebrales. Los invertebrados son de sangre fría (con la excepción de algunos grupos de insectos, incluyendo las abejas). No tienen piel, pelo, o escalas, casi siempre ponen huevos, y pueden tener hasta 8 apéndices (partes del cuerpo como brazos, piernas, cola, o aletas). Algunos invertebrados viven en el agua, algunos viven en la tierra y algunos pueden vivir en ambos ambientes.*

- **Fishes:** Are cold-blooded water-dwelling vertebrates with gills. Their bodies are covered with scales, some give birth to live young but most lay eggs, and they have fins. All fish require water for their main habitat. All fishes have gills to breathe oxygen from the water.

- **Peces:** *Son vertebrados de sangre fría que viven en el agua y respiran con agallas. Sus cuerpos están cubiertos con escamas y tienen aletas. Unos dan a luz crías vivas y otros ponen huevos. Todos los peces necesitan agua en su hábitat para sobrevivir y todos tienen agallas para respirar el oxígeno del agua.*

- **Amphibians:** Are cold-blooded vertebrates. Most amphibians have bare skin, lay eggs, and have four appendages. Amphibians can live on land, but most require a source of water to keep their skin moist.

- **Anfibios:** *Son vertebrados de sangre fría. La mayoría de los anfibios tienen piel sin pelo ni escamas, ponen huevos, y tienen cuatro apéndices (partes del cuerpo como brazos, piernas, cola, o aletas). Los anfibios pueden vivir en la tierra, pero unos necesitan agua para mantener su piel húmeda.*

- **Reptiles:** Are cold-blooded vertebrates. Their bodies are covered with scales. Some reptiles lay eggs and some give birth to live young. Most reptiles have four appendages, but snakes have none. Most reptiles use lungs to breathe air. Most reptiles live on land, with one famous exception being the marine iguana, which lives along the rocky shore and feeds on algae. Dinosaurs were reptiles.

- **Reptiles:** *Son vertebrados de sangre fría.Tienen cuerpos cubiertos con escamas. Unos dan a luz crías vivas y otros ponen huevos. Los reptiles tienen cuatro apéndices (partes del cuerpo como brazos , piernas, cola, o aletas), pero las serpientes no tienen ninguna. La mayoría de los reptiles usan pulmones para respirar aire. Muchos de los reptiles viven en la tierra, con la excepción de la famosa iguana marina, que vive en la orilla rocosa del mar y come algas. Los dinosaurios eran reptiles.*

- **Birds:** Are warm-blooded vertebrates. Their bodies are covered with feathers. All birds lay eggs. Their two front appendages are wings and their back appendages are feet. All birds are considered land-based, as they must come to shore to lay their eggs and raise their young, even aquatic birds.

- ***Pájaros:*** *Son vertebrados de sangre caliente. Tienen cuerpos cubiertos con plumas. Todos los pájaros ponen huevos, tienen dos alas y dos patas. Todos los pájaros son considerados que viven en la tierra, porque necesitan la orilla para poner sus huevos y cuidar sus crías, incluso los pájaros acuáticos.*

- **Mammals:** Are warm-blooded vertebrates. Their bodies are covered with skin and hair. Almost all mammals give birth to live young, with a couple of exceptions. Mammals use lungs to breathe air. Some mammals live in the water, while many live on land.

- ***Mamíferos:*** *Son vertebrados de sangre caliente. Tienen cuerpos cubiertos con piel y pelo. Casi todos los mamíferos dan a luz crías vivas, con algunas unas excepciones. Todos los mamíferos usan pulmones para respirar aire. Algunos mamíferos viven en el agua, mientras que muchos viven en la tierra.*

Scientist BINGO! Call Sheet

ENTOMOLOGIST: "I study insects. One of the things I do is find insects that destroy crops like fruits and vegetables." (ento = insect)

TAXONOMIST: "I look for similarities and differences in plants and animals. One of the things I do is classify animals and plants. For example, I decide if a dolphin is a fish or a mammal by studying its body and behavior." (taxis = arrangement)

MICROBIOLOGIST: "I study microscopic organisms, like bacteria. One thing I do is to look for microbes in food and water." (micro = small, bio = living organism)

HYDROLOGIST: "I study how water moves over the earth as part of the water cycle. I help people find the best way to use water and how to prevent floods." (hydro = water)

RESTORATION ECOLOGIST: "I help to restore damaged, unhealthy places into healthy ecosystems where plants and animals can live." (eco = house (Greek), more common use is environment)

METEOROLOGIST: "I predict the weather. One thing I do is to forecast the weather to help people, like pilots and fishermen, plan safe trips." (meteor = celestial phenomena)

BOTANIST: "I study plants. I identify plants' names, count how many there are, and tell people about their many different uses." (botan = of plants)

ENVIRONMENTAL LAWYER: "I use law to help protect our environment in court. For example, if a big company pollutes the air or water without following the rules, I take them to court to make them stop or pay for the damages." (environ = around)

MARINE BIOLOGIST: "I study ocean life. One thing I do is to study tidepool animals." (bio = living organism)

GEOLOGIST: "I study the Earth and rock formations. One thing I do is to study how the underwater mountains and canyons in the ocean were made." (geo = the earth)

GIS ANALYST: "I collect and analyze data to make maps on a computer. One thing I do is to make computer maps of habitats to help people understand where things are in the ocean." (GIS = Global Information Systems)

ENVIRONMENTAL EDUCATOR: "I teach people about the environment. One thing I do is to teach people how to protect the ocean." (environ = around)

ROV ENGINEER: "I build robots that go in the ocean. I can see what lives in the deep sea without getting wet!" (ROV = remotely operated vehicle)

OCEANOGRAPHER: "I study the ocean. Some things I study are where the currents go and the chemistry of the water."

HERPETOLOGIST: "I study reptiles. Some things I do are to find out where sea turtles live, how old they are, and how to protect them." (herpe = creeping things, common use is reptiles)

ORNITHOLOGIST: "I study birds. Some things I do are to catch birds, put an identification band on their leg, release them, and catch them again next year to see if their numbers are staying healthy." (orni = bird)

RESOURCE MANAGER: "I help to make important decisions about how people use resources. One thing I do is to make sure we leave enough resources for the future."

ICHTHYOLOGIST: "I study fish. Some things I do are to study how fish live, what they eat, and what things they need to stay healthy." (ichthy = fish)

ANIMAL HUSBANDRY SPECIALIST: "I help keep fish and other animals healthy in aquariums and zoos. Some things I do is to feed them and keep them and their cages clean."

ENVIRONMENTAL ENGINEER: "I design things to solve environmental problems. One thing I do is to design things to help our environment stay clean."

RESEARCH VESSEL OPERATOR: "I captain a boat to take scientists out on the ocean so they can do their research."

MARINE ENFORCEMENT OFFICER: "I enforce the law to protect the sanctuary. Some things I do are to make sure that humans are not disturbing ocean animals or dumping waste in the ocean."

SCIENTIFIC ILLUSTRATOR: "I make careful drawings of plants and animals for people to study closely and learn from."

Scientist BINGO!

Taxonomist	**Entomologist**	**Botanist**	**Hydrologist**	**Microbiologist**
Meterologist	**Restoration Ecologist**	**Environmental Lawyer**	**Marine Biologist**	**Botanist**
GIS Analyst	**Ornithologist**	**Environmental Educator**	**ROV Engineer**	**Environmental Educator**
Herpetologist	**Oceanographer**	**Resource Manager**	**Ichthyologist**	**Ornithologist**

Scientist BINGO!

Botanist	Meterologist	Marine Biologist	Microbiologist	Vessel Operator
Environmental Educator	GIS Analyst	ROV Engineer	Oceanographer	Environmental Lawyer
Ornithologist	Herpetologist	Ichthyologist	Animal Husbandry Specialist	ROV Engineer
Vessel Operator	Environmental Engineer	Scientific Illustrator	Entomologist	Resource Manager

Scientist BINGO!

Hydrologist	Restoration Ecologist	Meterologist	Taxonomist	Geologist
Marine Biologist	Geologist	GIS Analyst	Botanist	Herpetologist
Entomologist	Herpetologist	Environmental Lawyer	Environmental Educator	Animal Husbandry Specialist
Ichthyologist	Animal Husbandry Specialist	Environmental Engineer	Ornithologist	Taxonomist

Scientist BINGO!

Botanist	**Environmental Lawyer**	**Marine Biologist**	**Geologist**	**Marine Biologist**
Environmental Educator	**ROV Engineer**	**Oceanographer**	**Herpetologist**	**Oceanographer**
Resource Manager	**Hydrologist**	**Ichthyologist**	**Animal Husbandry Specialist**	**Botanist**
Resource Vessel Operator	**Marine Enforcement Manager**	**Scientific Illustrator**	**Entomologist**	**Restoration Ecologist**

Scientist BINGO!

Hydrologist	GIS Analyst	Environmental Educator	Restoration Ecologist	Geologist
Herpetologist	Ornithologist	Resource Manager	Ichthyologist	Entomologist
Environmental Engineer	Scientific Illustrator	Resource Vessel Operator	Marine Enforcement Officer	Resource Vessel Operator
Entomologist	Taxonomist	Microbiologist	Environmental Lawyer	Taxonomist

Scientist BINGO!

Environmental Educator	ROV Engineer	Botanist	GIS Analyst	ROV Engineer
Resource Manager	Ichthyologist	Ornithologist	Environmental Engineer	Ichthyologist
Marine Enforcement Officer	Herpetologist	Scientific Illustrator	Entomologist	Scientific Illustrator
Microbiologist	Marine Biologist	Hydrologist	Restoration Ecologist	Marine Biologist

Scientist BINGO!

Oceanographer	GIS Analyst	Ornithologist	Environmental Educator	Herpetologist
Animal Husbandry Specialist	Environmental Engineer	Resource Vessel Operator	Marine Enforcement Officer	Environmental Educator
Entomologist	ROV Engineer	Taxonomist	Microbiologist	Taxonomist
Environmental Lawyer	Restoration Ecologist	Meteorologist	Ichthyologist	Restoration Ecologist

Scientist BINGO!

Ornithologist	Resource Manager	Geologist	Animal Husbandry Specialist	Resource Manager
Resource Vessel Operator	Marine Enforcement Officer	Scientific Illustrator	Entomologist	Meteorologist
Microbiologist	GIS Analyst	Taxonomist	Hydrologist	ROV Engineer
Meteorologist	Botanist	Restoration Ecologist	ROV Engineer	Environmental Educator

Scientist BINGO!

Ichthyologist	Animal Husbandry Specialist	Resource Manager	Resource Vessel Operator	Animal Husbandry Specialist
Scientific Illustrator	Entomologist	Taxonomist	Microbiologist	Entomologist
Ornithologist	ROV Engineer	Restoration Ecologist	Meteorologist	Restoration Ecologist
Environmental Lawyer	Marine Biologist	Geologist	Geologist	Marine Biologist

Scientist BINGO!

Environmental Educator	Resource Vessel Operator	Marine Enforcement Officer	Scientific Illustrator	Environmental Lawyer
Taxonomist	Microbiologist	Marine Biologist	Hydrologist	Resource Manager
Meteorologist	Entomologist	Botanist	Environmental Lawyer	Microbiologist
Geologist	Restoration Ecologist	Environmental Educator	ROV Engineer	Hydrologist

Scientist BINGO!

Ichthyologist	Animal Husbandry Specialist	Resource Manager	Resource Vessel Operator	Animal Husbandry Specialist
Scientific Illustrator	Entomologist	Taxonomist	Microbiologist	Entomologist
Ornithologist	ROV Engineer	Restoration Ecologist	Meteorologist	Restoration Ecologist
Environmental Lawyer	Marine Biologist	Geologist	GIS Analyst	Marine Biologist

Scientist BINGO!

Environmental Educator	Resource Vessel Operator	Marine Enforcement Officer	Scientific Illustrator	Environmental Lawyer
Taxonomist	Microbiologist	Marine Biologist	Hydrologist	Resource Manager
Meteorologist	Entomologist	Botanist	Environmental Lawyer	Microbiologist
Geologist	Restoration Ecologist	Environmental Educator	ROV Engineer	Hydrologist

Scientist BINGO!

Ichthyologist	Animal Husbandry Specialist	Resource Manager	Resource Vessel Operator	Animal Husbandry Specialist
Scientific Illustrator	Entomologist	Taxonomist	Microbiologist	Entomologist
Ornithologist	ROV Engineer	Restoration Ecologist	Meteorologist	Restoration Ecologist
Environmental Lawyer	Marine Biologist	Geologist	GIS Analyst	Marine Biologist

Scientist BINGO!

Environmental Engineer	Resource Vessel Operator	Marine Enforcement Officer	Scientific Illustrator	Environmental Lawyer
Taxonomist	Microbiologist	Marine Biologist	Hydrologist	Resource Manager
Meteorologist	Entomologist	Botanist	Environmental Lawyer	Microbiologist
Geologist	Restoration Ecologist	Environmental Educator	ROV Engineer	Hydrologist

Food Chain Frenzy

LESSON 2.4

Summary

Students use language arts and sentence structuring to learn about food chains and the roles of producers, herbivores, carnivores and decomposers. Then, they use the species cards to make a Food Web. They wrap up their day with a rousing outdoor game of "Predator-Prey."

Learning Objectives

Students will be able to:

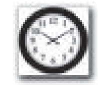
- Explain how energy from the sun provides the basis for food chains and webs
- Define a food chain and name one example
- Explain how food chains and food webs are related
- Explain how populations of organisms can be categorized by the functions they serve in an ecosystem

Background

To survive, all living things need energy and nutrients, and they develop adaptations in order to acquire them. Plants use photosynthesis to transform energy from the sun into plant energy (starch). They absorb nutrients from soil and water to make leaves, stems and flowers. Only a few types of organisms (plants, phytoplankton and algae) have the ability to take energy from the sun and "produce" starch, so they are called producers. Plants and other producers produce nutritious, energy-rich fruits and leaves that other organisms consume. Animals cannot produce their own energy, and must obtain nutrients and energy by consuming producers and other animals.

Within a natural community, organisms interact with each other in a complex relationship of "who eats whom." This dynamic is referred to as a food web, or the web of life. Some organisms are predators, some are preyed upon, others are consumed after they have died. In a food chain, different organisms have different roles. Some animals, called herbivores, eat plants or other producers. Organisms eating mostly animals are called carnivores. Organisms that eat both plants and animals are called omnivores. Some organisms, called decomposers specialize in getting stored nutrients and energy from dead and decaying plants and animals. Food chains on land and ocean communities both have organisms representing the roles of herbivore, carnivore, and omnivore, but the organisms are different.

A food web consists of a series of food chains, — a direct line of who eats whom. Combined together they create a complex web of survival that occurs in all communities. Food chains show how energy moves from organism to organism. A food chain always begins with the sun, which provides light energy to producers. Producers are able to capture solar energy (light) and transform it into starch, or sugar.



Duration

What is a Food Chain?:
20 minutes
Food Chain game:
20 minutes
Predator/Prey game:
15-30 minutes

Teacher Prep

1. Read background
2. Select species cards for the food chain/web activities depending on the size of your class. Refer to the Sanctuary Food Webs to select cards—you must include the sun and plant cards
3. Gather materials for games

Food Chain Frenzy

LESSON 2.4

Materials

For Food Web Game

- Colored chalk
- Ball of string
- Selected species cards, one per student

For Predator/Prey game:

- An empty area 30 x 60 feet wide like a playing field or playground
- Whistle
- Stopwatch
- Three safety vests or athletic pennies
- Four safety cones or other type of markers
- Arm bands, one for each student, equal numbers of red, white, and blue (can be made with colored paper and staples)
- Equal numbers of red, white, and blue chips: the number of chips of each color must be twice the number of students

The terms "food chain" and "food web" are often used interchangeably, but a food chain is different from a food web. A food chain is a simplified illustration of the predator-prey relationships (who eats whom) between a few organisms within a community. It shows the transfer of energy from one feeding level to another (from producer to consumer, etc).
A food web can be illustrated by the flow of energy, starting with the sun, as it moves through a community showing many different food chains and the interconnected feeding relationships within a community or ecosystem.

A diagram of a food chain starts with the sun, the source of energy, at the left. The next link in the food chain, a producer, is written to the right of the sun. The animal consumer who eats that plant (herbivore) is written to the right of that, and so on.

Examples of land-based and ocean-based food chains are represented below:

Land-based food chain

Sun → Grass → Deer → Mountain Lion
Sun → Producer → Herbivore → Carnivore

Ocean-based food chain

Sun → Kelp → Sea Urchin → Sea otter
Sun → Producer → Herbivore → Carnivore

In a food chain, energy is passed from one link to another. Organisms along a food chain pass on much less energy (in the form of body mass) than they receive. In other words, energy is "lost" at each stage, although even in death, animals and plants contain enough stored energy in their bodies to supply many decomposers.

Food Chain Frenzy

Activity Procedure

Making Food Chain Diagrams

1. Introduce the concept of food chains. Living things are connected to what they eat, and what eats them. Give an example of a simple food chain that people are a part of. For example, "What do people eat for breakfast?" Write the following phrases on the board. Use colored chalk to emphasize the words in bold.
   Phrase 1: "The **sun** provides **energy** to the **corn**, which gets **nutrients** from the **soil**. The **chicken** gets nutrients and **energy** from eating the **corn** and produces an **egg**. **People** get **nutrients and energy** from eating the **egg**."
   Phrase 2: "The **sun** provides **energy** to the oat **plant**, which gets **nutrients** from the **soil**. **People** get **nutrients and energy** from eating the **oats** (cereal)."

2. Look at the sentences on the board and ask students to see if they can replace the words **nutrients** and **energy**, along with the connecting words, with arrows from one subject to another.

Give an example showing the flow of **energy**:
Sun ⟶ corn (producer) ⟶ chicken or egg (consumer) ⟶ people (consumer)
Sun ⟶ oats (producer) ⟶ people

You could also make a chain showing the flow of **nutrients**:
Soil ⟶ corn (producer) ⟶ chicken or egg (consumer) ⟶ people (consumer)
Soil ⟶ oats (producer) ⟶ people(consumer)

In these two examples, the source (sun or soil) is the only thing that changes. When studying the flow of energy in a food chain, we start with the sun. When looking at the flow of nutrients, we start with soil. For the rest of the lesson, we will focus on the flow of **energy** as it moves through the food chain, starting with the sun.

3. Now write a sentence describing a food chain in a marine community. The sun provides energy to phytoplankton. Krill get energy from eating phytoplankton. Fish get energy from eating krill. People get energy from eating fish. A food chain diagram would look like this:
   Food Chain: ⟶ Sun ⟶ phytoplankton ⟶ krill ⟶ fish ⟶ people

Assigning Roles

4. In a food chain, organisms are assigned roles based on the type of food they usually eat. The handout, Examples of Food Chains in the Monterey Bay National Marine Sanctuary shows the different roles for many marine organisms. Review with students, or write this on the board:
   a. Producers: photosynthetic organisms that convert solar energy to starch. (Examples: phytoplankton, algae, plants)

Vocabulary

Carnivore
Consumer (primary, secondary, and tertiary)
Decomposer
Detritivore
Food chain
Food web
Herbivore
Omnivore
Predator
Prey
Producer

Journal Prompt Closing Activity

In their journals, have students draw pictures of organisms in an ocean food web. Make a class mural showing the interrelationships of all the organisms on the species cards with a conservation message.

b. Consumers: eat other organisms for food. Examples follow:
- Herbivores: these animals eat producers most of the time (Eelgrass)
- Omnivores: these animals eat producers and other consumers (Crab)
- Carnivores: these animals eat mostly other animals (Sea otter)
- Top carnivores: these animals eat exclusively other animals (Orca)

c. Decomposers: eat dead and decomposing organisms of all sorts, including producers, herbivores, omnivores and carnivores. Decomposers are the ultimate omnivores. (Example: *bacteria, bat stars, sea cucumbers*)

5. Next, apply roles to each of the steps in the food chain. Use colored chalk for each role:
Food Chain: Sun → phytoplankton → krill → fish → people
Roles: Source → producer → herbivore → carnivore → top carnivore

6. Refer to the handout, Examples of Food Chains in the Monterey Bay National Marine Sanctuary for more ideas. Practice writing sentences, converting them to food chain diagrams, and assigning roles until everyone understands.

Playing the food chain game

7. Refer to Examples of the Food Chains in Monterey Bay...and select one, two, three or four food webs based on the number of students you have. Pull out species cards for each species in your selected food web(s) including the sun and plant cards.

8. Start the activity with an example. Select a food chain example from the Examples of Food Chains in the Monterey Bay National Marine Sanctuary handout and find the cards representing that example. Select 5 volunteers from the class to represent different roles in the food chain and have them line up in front of the rest of the class. Hand one species card to each student. Ask students to read their cards aloud so that everyone knows what they are.

9. Place the student representing the Sun on the left and hand the end of string to the student. The next in line is a student representing a producer, then an herbivore, an omnivore or carnivore, a top carnivore and a decomposer. Pass the ball of string to each student, having each student hold onto the string as it passes by them. Show the class that this is an example of a **food chain.**

10. Play the game again, using all the students. Hand species cards to every student and direct them to stand in a circle. Find the student who has the **Sun** card. As the source of energy on Earth, the Sun always starts the game. The Sun starts with the end of string, and the ball passes through the different food chain roles until everyone is hold the string. Tell your students that they have just created a **food web**.

11. While the class is still in a circle holding the string, ask them to gently pull their string to feel their connection to each other. Discuss the fact that the flow of energy connects all living things in a community to one another. Think about what would happen if there were no Sun, or producers, or decomposers? Every role is essential in the food web.

12. Now that they know how they are all connected in the food web, introduce an impact on the food chain and make predictions as to how it will impact the other players. To do more than one of these scenarios, the students who are impacted will drop their string at their feet and pick it up again after each scenario is finished.

13. Discuss examples of how the food chain could be altered:
    a. Phytoplankton are plants. If herbicide, which kills plants got into the ocean it could kill phytoplankton. What organisms would be impacted if phytoplankton died? Have the student in the role of phytoplankton tug gently on the string. Organisms that feel the tug would be affected by the loss of phytoplankton. This could happen if people dump herbicides into the ocean or into storm drains that flow into the ocean.
    b. Mussels are omnivores that feed on tiny particles drifting the water. Mussels are consumed by sea otters and birds. If there were toxins in the water that killed mussels, what other organisms would be affected? Have the student playing the mussel role tug gently on the string. Organisms that feel the tug would be affected by the loss of mussels. This is why keeping our ocean free from pesticides, herbicides and other toxins is important.

Playing the predator/prey game

1. Explain to students that they are going to play a game that demonstrates what happens in food webs in the ocean ecosystem and how natural systems remain stable over time.

2. Set up boundaries on the playing field by placing safety cones or other markers around the field in a rectangle 30 feet by 60 feet. Spread out the colored chips at a wide end of the field (the number of chips should twice be the number of students).

3. Explain to students each chip color represents a different type of prey:
   red = fish
   white = clams
   blue = squid

4. Choose two or three students to be top carnivores, sharks (not the fastest kids or it will be a very short game!). These students wear safety vests or some other means of identification, and will represent sharks.

Activity Extensions

"Go Fish" Card Game:
Use the species cards to play an old standard card game. In "Go Fish", students take turns asking each other for a particular card. If the student who is asked does not have the card, she/he says "Go Fish!" and the student whose turn it is takes a card from the pile. Students can lay their cards out in front of them rather than hold them in their hands.
Goal: One card in each hand must come from one or two habitats
Questions to ask for cards (write these questions on the board as prompts for students):
Do you have something that lives:
- in the open ocean?
- in a wetland?
- in a sandy beach?
- in a kelp forest?
- on the ocean floor?
- in the deep ocean?
- on the walls of the submarine canyon?
- in watersheds?
- in all ocean environments? (plankton, detritivores/decomposers/ bacteria)

Need to win: all five cards in hand must be from one or two habitats

5. Give each remaining student an armband. The armbands must be visible at all times. Each arm band color represents a different type of predator:
   a. red = sea lions
   b. white = sea otters
   c. blue = harbor seals.

Round 1:

- Students with armbands line up on the end of the field opposite to the scattered "food." Predators, with safety vests, stand in the center of field.
- At the sound of the whistle, all the sea lions, sea otters, and harbor seals run across the field to the other side, where they must pick up one chip (of any color), then run back to the starting point as soon as possible.
- The sharks try to "catch" their prey by gently tagging running students. If a student is tagged, the predator escorts them off the field. Repeat this twice. The sea lions, sea otters, and harbor seals need to gather three chips in three trials to survive.
- After three minutes, stop playing. Determine how many students gathered enough food to survive without being eaten. Those who were eaten or didn't gather enough food did not survive.
- Remind students that they just demonstrated what occurs in an ecosystem. Top predators like sharks limit the number of sea lions, sea otters, and harbor seals. This means that the surviving predators have enough prey to survive. What would happen if there were no top predators?

Round 2:

- Repeat as in Round 1, except now sea lions, sea otters, and harbor seals must prey on a specific food item, the color of chip that corresponds to their armband. Sea lions eat fish, sea otters eat only clams, and harbor seals eat only squid.
- Discuss the results of Round 2:. Was it easier or harder to get enough food when each predator hunted only one type of prey? This is why some species specialize and others will eat whatever they can.

Round 3:

- Pretend that an oil spill has occurred and many prey items died. Remove some of the chips, so there is less food to go around.
- Discuss the results of Round 3. With less food available, was it easier for the sharks to tag their prey?

Round 4:

- Explain to students that when one species is in short supply, it may switch to eating a more abundant species. Pretend there is a decline of squid in the community, so sea otters and harbor seals now both eat clams. What happens to the game this time? Be sure to wrap up the game with a discussion of what they think happens in the community when food is scarce.

Food Chains in the Monterey Bay National Marine Sanctuary

Food Chain Example #1

Primary Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers	Decomposers/Detritavores
Phytoplankton	Zooplankton	Leatherback Sea Turtle	Northern Elephant Seal	Bacteria
	Spot Prawn	Humpback Whale	Orca	Ghost Shrimp
	Blue Rockfish	Steelhead Trout	Brown Pelican	California Sea Cucumber
	Purple-Striped Jelly	Ocean Sunfish	White Shark	
		Giant Pacific Octopus	Human	

Food Chain Example #2

Primary Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers	Decomposers/Detritavores
Giant Kelp	Pinto Abalone	Black Oystercatcher	White Shark	Bacteria
Turkish Towel	Jeweled Top Snail	Southern Sea Otter	Human	California Sea Cucumber
Phytoplankton	Northern Kelp Crab	Leopard Shark	Harbor Seal	Spot Prawn
	Limpet	Sunflower Star	California Sea Lion	
	Blue Rockfish	Vermillion Rockfish		
	Zooplankton			

Food Chain Example #3

Primary Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers	Decomposers/Detritavores
Phytoplankton	Red Volcano Sponge	Wolf-eel	Sea Lion	Bacteria
	Sea Pen	Oplaescent Nudibranch	Harbor Seal	California Sea Cucumber
	Sand Dollar	Sunflower Star	White Shark	Spot Prawn
	White-Plumed Anemone	Vermillion Rockfish	Human	
	Brittle Star	Giant Green Anemone		
	Zooplankton	Sanddab		

Food Chain Example #4

Primary Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers	Decomposers/Detritavores
Eelgrass	Arrow Goby	Polychaete Worm	Human	Bacteria
Phytoplankton	Fat Inkeeper Worm	Marbled Godwit	White Shark	Ghost Shrimp
	Sand Crab	Snowy Plover		
	Striped Shore Crab	Great Blue Heron		
	Beachhopper	Leopard Shark		
	Zooplankton			

What is a Watershed?

LESSON 3.1

Summary

Students learn about topography and how the “lay of the land” affects the path water takes on its journey through watersheds to the ocean. After viewing topographic maps and learning how to read them, students create their own watershed model and watch what happens in a ‘rainstorm.’

Learning Objectives

Students will be able to:

- Describe the role of topography in the flow of water through a watershed
- Look at a topographic map and recognize elevations and contour lines
- Know the name of the watershed they live in and its main watercourse
- Describe how they are connected to the ocean

Background

Topography, also known as geomorphometry, is the study of the Earth’s surface features. Topography studies the three-dimensional aspect of the surface, sometimes called relief or terrain. Topographic maps show us the “highs and lows” of the land – mountains are high spots, valleys are low spots. Contour lines represent elevation, or the height of a feature above sea level. Other methods to show elevation include using color and shading. By learning how to read topographic maps, we can develop a sort of 3-D view of an area, including mountains, lakes, rivers and other features of the land.

A watershed is considered the region of land whose water drains into a specified body of water. Water flows are determined by the shape of the land and are affected by elevation. Water moves from higher to lower elevations as gravity pulls water downward. The water in a watershed follows the sloping of the land downward. Sea level is the lowest elevation in nearly all parts of the world (Death Valley National Monument is an exception, with an elevation lower than sea level in some places). Water travels for miles down mountains, hills, valleys, rivers and creeks, following gravity until it eventually flows into the sea.

We live near the coast, so our elevation is low. We live near the end of a watershed, close to where the water enters the ocean. Runoff from houses or pollution can also flow downhill and mix with the water as it flows to the ocean. In this lesson, we study how water flows from land into the Monterey region and out to Sanctuary waters.

Duration

Topography: 20 minutes
Make Your Own Watershed: 20 minutes
Closing Activity: 20 minutes

Teacher Prep

1. Read activity background
2. Collect materials

Materials

- Topo Map Sample (included)
- Monterey Bay National Marine Sanctuary poster
- Blue food coloring
- Spray bottles filled with water and blue food coloring
- Stiff paper: photocopy paper or card stock
- A roll of plastic wrap
- Trays: 1 per group Shallow cookie sheets, baking dishes, or flat microwave dishes work best.
- Newspaper (for spills)

What is a Watershed?

LESSON 3.1

Vocabulary

Contour Lines
Elevation
Sea Level
Topographic map
Topography
Watershed

Activity Procedure

1. Distribute as a handout the "Topo Worksheet" or make an overhead of it. Look at contour lines, and see if you can find what areas are highest, and what are lowest. Some contour lines have numbers, these represent the number of feet above sea level. As you follow the contour lines, you can begin to understand how elevation changes in an area. Also look at the lakes and rivers, represented by the color blue. These will have the lowest elevation. Water always flows to the lowest point. Look at other features including roads (shown in red or black) and structures (black squares).

2. Now look at the map of the Monterey Bay National Marine Sanctuary. On this map, the contour lines on land are missing. Elevation on this map is illustrated by color and shading. The highest points are brown. Middle elevation spots are yellow, and low elevation is green. Rivers are in blue. Contour lines are included in the ocean. These lines represent the elevation of the land below sea level. Look how deep the land is under the surface of the ocean.

Make your own watershed

1. Tell students they are going to build a model of a watershed and observe what happens in a rainstorm.

2. Divide students into groups of four. Each group will gather stiff paper, an aluminum tray, spray bottle and newspaper (for spills). Place the newspaper on a flat surface and place the metal tray on top of it. Each group will create a landscape by crumpling six pieces of paper into large and medium balls. They will place the crumpled balls in the pan, spreading them out so there are high spots (mountains) and low spots (valleys). Ask students to mark places where they think water will accumulate. You may use different colored pens to designate different regions. For example: ridges may be in brown, hillsides in green, valleys in blue, and toxics in red.

3. Tell students they will soon experience a 'rainstorm.' Where do they think water will flow and collect in the model? Ask the students to spray (a fine mist works best) water on the model and watch the path a drop of water takes across the watershed and into the watercourse and valleys.

4. Tell them to watch how the smaller drops gather together to become bigger drops. Pay special attention to how the shape of the model affects the flow of the water. Look for a pattern to how the water flows through their model. The drainage pattern of water through a watershed creates a "branching pattern," just like the branches of a tree. Just as smaller branches grow on larger branches which grow on the trunk, small streams, called tributaries, feed into larger streams and rivers, which then feed into lakes or, as is the case along the central coast, the ocean.

5. After the water has collected in several spots, ask the students to count how many watersheds they can find in their model by noting where water has collected.

6. Start a discussion with the class about what they learned. Did water flow faster in some areas than others? In general, water flows faster in steeper mountains, and the water ends up in the deeper valleys.

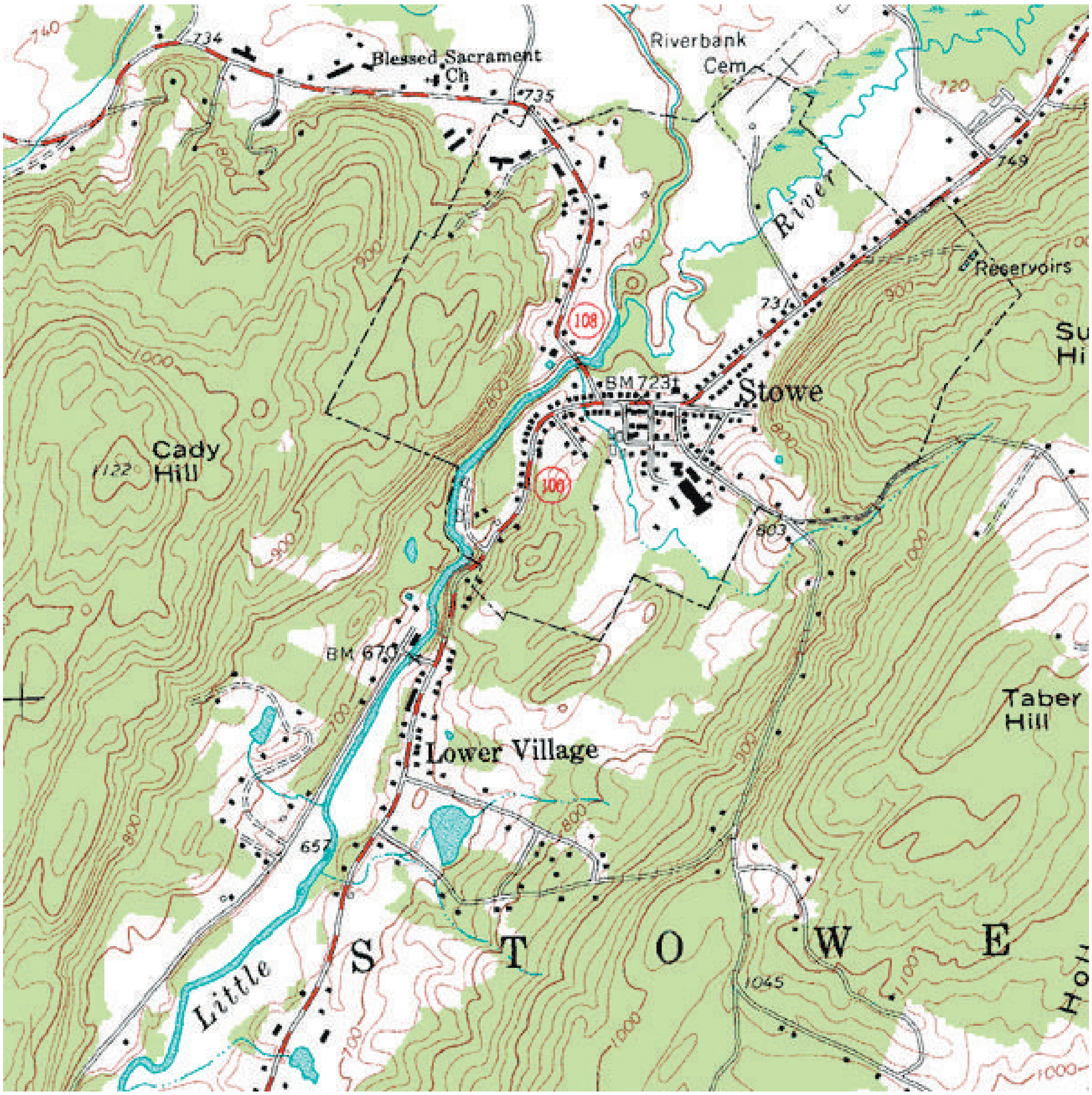
7. Ask students what would happen if you changed the “mountains” of your models? (the watersheds would change). What if the watershed was covered with soil? (Most of the water would sink into the soil instead of running off). What if you put roads on the watershed? (the water would flow faster over roads than soil). How would buildings change the flow? (Buildings would alter the flow, water would be diverted around the buildings). Have students discuss how water would flow differently across an urban landscape that has houses and roads, to a rural or agricultural landscape.

Journal Prompt Closing Activity

Option 1: Have students write their own “raindrop” story in their journals or draw a picture of a raindrop, starting as it falls from the clouds on its journey through a watershed to the ocean. Where would the drop fall? Where would it go next? Would it combine with other drops? Where would it flow into the sea? How long would it take?

Option 2: Have small groups work together to create a skit about a raindrop. They can act out the parts or draw storyboard pictures to tell the story.

Topography Practice



Locating Groundwater Pollution

LESSON 3.2

Summary

Students learn what groundwater is and make a groundwater model, hiding a "contaminant" in their model. Another group conducts "groundwater testing" to find the contaminants and map them on their worksheets.

Learning Objectives

Students will be able to:

- Explain that water flows underground and settles in underground areas called aquifers
- Describe how water can mix with underground pollutants
- Explain that pollutants from land can percolate into groundwater supplies, contaminating them
- Understand that contaminants in groundwater will follow gravity towards the ocean

Background

Watersheds contain both surface runoff and groundwater. During rains, some water flows across the surface of land, moving down the land as elevation drops until it joins local creeks, streams, or rivers. This water is termed surface runoff.

Much of our rainwater seeps into the ground and follows gravity to open spaces under the surface of the soil, filling the air spaces between the soil, rock and clay. This water is known as groundwater. Water is pulled downwards by gravity until it reaches a surface it cannot penetrate. Large underground areas where groundwater accumulates are called aquifers. Groundwater moves very slowly, following the underground topography of the watershed towards the ocean. Although not visible to us, groundwater comprises over 95% of the liquid freshwater on earth.

People pump groundwater from under the surface of the land for use in their homes. Farmers pump groundwater to water their crops. Along the coast, when people use groundwater faster than it can be replaced by natural processes, saltwater can enter into (intrude) the groundwater. This saltwater intrusion can make the water unsafe for people to drink and can make the water unusable on crops. In Salinas Valley, at times, saltwater has intruded groundwater almost six miles inland, making the groundwater too salty for either city or agricultural use.

Duration

Groundwater Pollution Testing: 60 minutes

Teacher Prep

1. Photocopy Groundwater Pollution worksheets, one per group
2. Collect materials

Materials

- Groundwater Pollution worksheet
- Aluminum baking pans or fast-food salad containers, one per group
- Sand (enough to fill each pan)
- Plastic Straws, 1 per group, or paper straws, 10 per group
- Beaker or containers of water to rinse straws
- Spray bottles
- White sheet of papers, one or two per group
- Four different colors of Kool-Aid powder
- Water
- Books to raise one end of pan one inch, one per group

Locating Groundwater Pollution

LESSON 3.2

Vocabulary

Aquifer
Contaminant
Groundwater
Non-point Source Pollution
Point Source Pollution
Rainwater
Runoff
Topography
Saltwater Intrusion

Activity Extension

Invite a guest speaker to talk about groundwater issues, include saltwater intrusion, changing waste-water into safe water, and pollution prevention. Your local water pollution control agency usually has presentations geared for students that include a groundwater model. Contact Monterey County Waste Water Treatment Plant or City of Watsonville for a guest speaker on groundwater contamination.

Activity Procedure

1. Show students Figure 3.2.1, Groundwater Model. Ask students if they have thought about where the water they use every day comes from. Often it comes from wells that pump water from deep underground. Share some of these facts with your students:
   - Rain slowly seeps (or percolates) into the earth to become groundwater, later surfacing in a spring, river, or lakes.
   - Groundwater is stored beneath the surface of the land, filling the spaces between the soil, rock and clay- known as naturally occurring storage systems called aquifers.
   - Groundwater is one of the main sources of drinking water for many cities. Groundwater is pumped out of the ground through wells.
   - Over time, groundwater can become polluted due to polluted surface water, landfills, industrial waste, agriculture chemicals, or underground storage tanks.
   - Groundwater near the coast can also be contaminated with seawater, when water from the aquifers is pumped faster than it can be recharged from rain.
   - Groundwater is difficult to monitor (test over time), pollution may not be detected until it reaches the well.

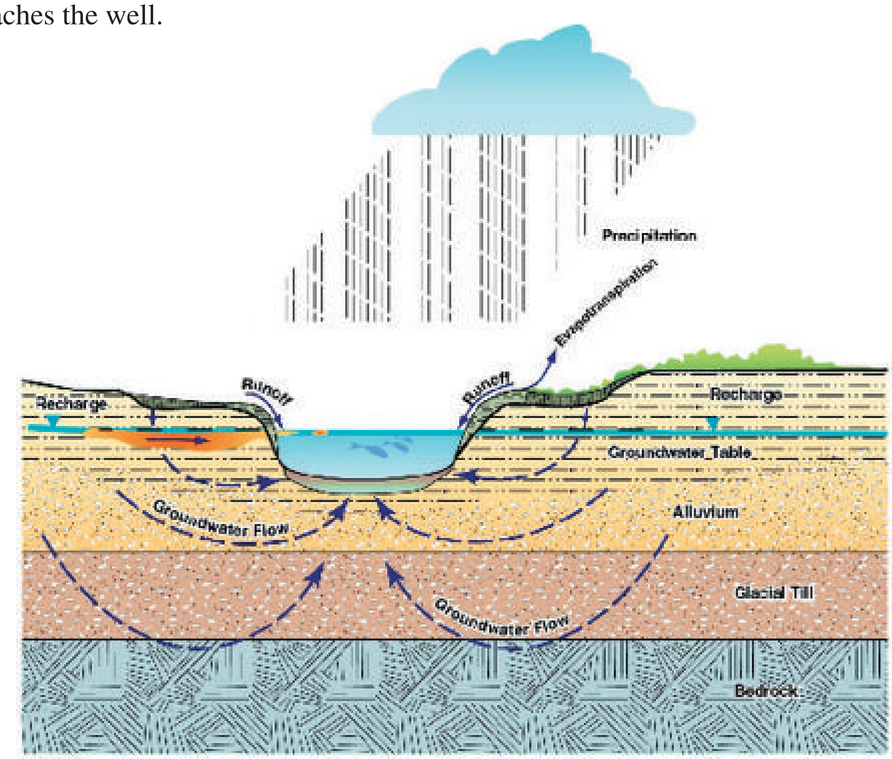


Figure 3.2.1 Groundwater Model

2. Tell students that they are going to learn about how water goes underground to become groundwater, and how groundwater can become polluted. Break the class into groups of 3 or 4. Hand out a Groundwater Pollution worksheet to each group.

Locating Groundwater Pollution

LESSON 3.2

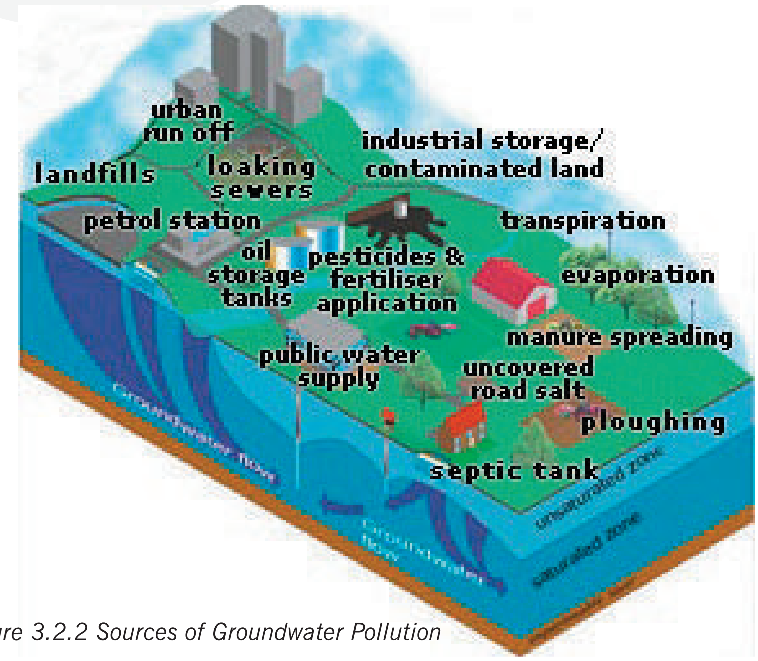


Figure 3.2.2 Sources of Groundwater Pollution

3. Bring out the bucket of sand and pans and send one student from each group to get a pan and fill it half way with sand (or do this in advance, and have students collect filled sand trays.) Be sure they label their pan with “Mountains” on one side and “Ocean” on the other side.

4. Have another student collect the colored Kool-Aid contaminant and 10 straws.

5. Write a pollutant-key on the board for students to use to during their investigation.

Pollutant-Key	(example)
Green Kool-Aid	Nitrates (from leaching landfills)
Red Kool-Aid	Pesticides (from agriculture)
Blue Kool-Aid	Salt and minerals (from saltwater intrusion)
Yellow Kool-Aid	Coliform bacteria (from a leaking septic tank)

6. Tell students to bury their pollutants in the sand, and not let other groups see where they hid them. Tell students to mark an X on their worksheets showing where they buried their pollutant and note the pollution source or color (i.e. agriculture, septic tank, landfill, saltwater intrusion). Tell groups to place the side of the pan marked “Mountains” on a book to create an incline.

7. Provide spray bottles, beakers, or containers with water for each group to use.

8. Have each group spray the top of the sand with water to simulate rain that has been falling on land over the years until the sand is saturated. No surface runoff should occur.

Journal Prompt Closing Activity

Groups write a song or a rap about groundwater contamination— the importance of clean water, and how it becomes contaminated.

9. Provide each group with 5-10 straws to stick into the sand and explain the following procedure or write it on the board:
   • Note the location of sample test sites by marking TS (for Test Site) on their worksheets
   • Hold straw vertically over the sand, select a spot to sample, and gently press the straw down into the soil. Mark the spot on your worksheet.
   • Plug the top of the straw with a finger to avoid losing any of the sample
   • Keeping a finger on the top of the straw, lift the straw from the sand.
   • Release the straw over a sheet of white paper and look for contaminated sand
   • Repeat test until all contamination sites have been found.
   • When a contamination site is found, mark the location on the data sheet with a large C and use the pollutant-key to identify the type of pollutant.

10. Have each group compare their results with the teams that hid the contaminants. Did they find all the hidden locations? Did contaminants show up in places they weren't hidden? Why?

11. When the testing is complete, ask students what they think would happen if heavy rains washed the contaminants out of their isolated locations. For example, in 2005 Hurricane Katrina flooded Louisiana and the surrounding region for miles. What might have happened to contaminants hidden in the ground? Where would they have ended up?

12. Have students return sand to the bucket it came from. Fortunately, Kool-Aid is not toxic and can be easily rinsed from sand. Have student volunteers rinse the sand before returning it to where it was collected.

Groundwater Pollution

Contaminación de Aguas Subterráneas

LESSON 3.2

Team Name /Nombre del Grupo________________

Site Map / Mapa del Sitio

1. Without showing your neighbors, bury your pollutant in the sand. In the box below, mark X's to show where you buried your pollutants and the pollutant sources (i.e. agriculture, septic tank, landfill, saltwater intrusion).
   Entierra tus contaminantes en la arena y marca con una X en donde están y de donde vienen (agricultura, océano, la casa con tanque séptico, el basurero).

2. Trade your pan with another group.
   Intercambia tu bandeja con otro grupo.

3. Using a straw, collect sand samples. For each test you do, mark TS on the map below to represent each test site.
   Toma muestras de la arena con el popote y en la hoja de trabajo marca cada muestra con TS.

4. When you find a contamination site mark the location with a large C, then use the pollutant-key to find the source and type of pollutant and write it next to the C-site.
   Cuando encuentres el sitio contaminado, márcalo con una C, después busca en la clave para contaminantes el tipo de contaminante y de donde viene y escribelo junto al sitio C.

Mountains

Ocean

Who Polluted Our Creek?

LESSON 3.3

Summary

In these classroom activities, students practice water quality testing procedures for pH, turbidity, nitrates, phosphates, temperature, and dissolved oxygen. This activity helps students become familiar with water quality test kits prior to taking a field trip to a nearby creek (Lesson 3.4). This activity may be conducted as a teacher demonstration or in small groups that rotate through the six stations.

Learning Objectives

Students will be able to:

- Make water quality observations and develop a hypothesis
- Recognize three sources of water pollution
- Conduct six water quality tests in the classroom
- Name three ways that their actions could decrease water pollution
- Describe how local streams and the Monterey Bay National Marine Sanctuary are connected

Background

The Monterey Bay National Marine Sanctuary has a mandate to protect resources in the Sanctuary from pollution. While some polluting activities are easy to detect and stop, one of the most difficult sources of pollution to identify and prevent is non-point source pollution -- pollution coming from sources that cannot be directly located. Runoff, water that does not soak into the ground, can originate miles away in urban areas, agricultural land, construction sites, lawns, and some industries, such as mining. Polluted runoff can contain heavy metals, salts, sediment, nutrients, and bacteria. All of these can injure or kill wildlife, or severely alter the natural balance of marine communities.

In urban areas, pollutants from backyards and parking lots are carried during rainstorms into storm drains that flow directly into the ocean. Even cities miles from the coast are part of the watershed, and water from these cities enters storm drains that eventually follow gravity to the sea. The larger the population of people in a watershed, the more homes, businesses and industries there are to contribute polluted runoff water to a storm drain that eventually finds its way into the Monterey Bay National Marine Sanctuary. Many of our daily activities may contribute to non-point source pollution without our knowledge, including lawn and landscape maintenance, where excessive amounts of pesticides and fertilizers may get washed into creeks. Changing the fluids in a car engine or oil leaks can leak petrochemicals into the environment. Construction projects like homes, highways and shopping malls can cause erosion and mud to flow into the ocean.

Duration

Review of Water Pollution Causes: 10 minutes
Who Polluted Our Creek?: 30 minutes
Testing Our Creek: 60 minutes

Teacher Prep

1. Read activity background
2. Collect "pollution" materials in advance (you can usually get free empty film canisters at a photo processing store
3. Read through the water quality testing procedures and look through the water quality kit
4. If doing as a demonstration, photocopy one Water Quality Data Sheet and one set of Water Quality Instruction Sheets
5. If doing in small groups, photocopy six Water Quality Data Sheets and six sets of Water Quality Instruction Sheets, and set up six water quality stations, leaving instructions at each station

Vocabulary

Dissolved oxygen
Erosion
Nitrates
Pesticides
pH
Phosphates
Pollution
Runoff
Storm drain
Temperature
Turbidity
Water quality

Who Polluted Our Creek?

LESSON 3.3

Materials

- One copy of the story: *Who Polluted Our Creek?*
- One clear plastic bin filled with water
- LaMotte water quality test kit (from watershed science kit)
- Water Quality Data Sheet
- Water Quality Instruction Sheets
- Six cups or bowls

Water Pollution:

- Fifteen film canisters filled and labeled with the "pollutant" name (i.e. Acid)
- Acid (lemon juice)
- Manure (pepper)
- Pesticides (purple kool-aid powder)
- Fertilizers (green kool-aid powder)
- Garbage (chopped up pieces of food or scraps of fabric)
- Oil (soy sauce)
- Antifreeze (soda—fill just before class)
- Soil
- Leaves
- Soap (liquid soap or detergent)
- PCB's (milk)
- Trash (cigarette butts and scraps)
- Balloons (balloon pieces)
- Sewage (vinegar)
- Refrigerators and tires (marshmallows and black licorice—can use larger container)

We can tell something about the health of the environment in an area like a watershed by checking its water quality. Several different water characteristics can be evaluated using general observations and simple chemistry. Six key water quality measurements are pH, turbidity, dissolved oxygen, temperature, phosphates, and nitrates and are described below. The worksheets attached to this lesson explain why these tests are important and how to evaluate samples for their health.

Scientists measure water quality in the same area over many different days, months, or years in order to completely understand all the characteristics of the water in a particular area. Good water quality promotes good watershed health and may increase the numbers and types of organisms found in a watershed and in the ocean.

Activity Procedure

Water Pollution Causes

1. Start a discussion with students about water pollution. Water becomes polluted when things get into it that don't belong. On the board, list examples of things that do not belong in water. Your list might include oil from cars, soap, litter, chemical spills, fertilizers, pesticides, sewage, dirt or soil, trash, human waste, run-off from streets, bacteria, sediments, etc. Where does pollution come from? Discuss the sources of pollution entering the sanctuary from ocean dumping, or from creeks and streams that bring pollution with them from the land. When polluted waterways flow into the ocean, they their pollutants flow right into sanctuary waters. Ask students: Have you ever gone to the beach and seen a sign that read, "Beach closed due to bacterial contamination?" The water looks clean, but the sign says it is not. How do we know a body of water is polluted if we cannot see it?

2. Tell students that The Monterey Bay National Marine Sanctuary is required to protect natural resources in the ocean, and that includes protecting them harmful pollution. In order to achieve this goal an extensive water quality monitoring network composed of scientists, volunteers and educators conduct studies to monitor the health of creeks and streams flowing into sanctuary waters. These studies involve several tests that help scientists determine if there are pollutants in the water. Today, we will pretend to be sanctuary scientists, and see if we can find pollutants in our water samples.

Who Polluted Our Creek?

LESSON 3.3

Who Polluted Our Creek?

1. Place the plastic bin with clean water in the middle of the classroom and have all students stand or sit around it. Tell students: This water represents your clean local creek. Ask students: Would you drink this water? Would you swim or play in it? Would you eat fish from it? Why or why not?

2. Hand out the labeled containers with pollutants to students and tell them to listen carefully for the pollutant written on the outside of their containers. When they hear their pollutant, they take off the lid and pour the contents into the “creek.” Tell studentsto pay close attention to the story in order to learn who polluted the creek.

3. Read the story, “Who Polluted Our Creek?” slowly enough for students to follow along. After you have read the story, have an open discussion about the questions at the end of the story. Explain that we will use tests to determine who polluted the creek.

4. Before the students begin testing, have them write a hypothesis, or an educated guess, on their data sheets or in their journals, about who they think polluted the creek. For more information on writing hypothesis, see Appendix C: The Scientific Method.

3. You should have previously set up the six water quality stations, leaving the appropriate instructions at each station. Following the Water Quality Instruction Sheets, go to each water quality station and discuss what each test means, then go over the test procedures. Go over the data worksheet with the class and help them fill the answers out correctly.

4. If you are doing this as a teacher demonstration: Review each test procedure then conduct the test. Fill out the Water Quality Data Sheet as you go with the class. Choose students to act as your assistants and data collectors.

5. Have students review the test procedures first, then break students into six groups.

6. Hand out a Water Quality Data Sheet to each group. Assign each group a station.

7. Tell students to collect a water sample from the polluted creek in a clean cup or bowl. Then make observations of your sample and develop a hypothesis. Then conduct the six different tests on this sample as you rotate through the stations. Record your findings on the Water Quality Data Sheets as you conduct the tests. Tell the groups when to move to the next station.

8. Once students have completed all the tests have each group share their results and discuss what they observed. Ask them to compare their results to the hypothesis they wrote at the beginning. Was their hypothesis correct? Why or why not?

Journal Prompt Closing Activity

Ask students to write and discuss what they think could have been done to prevent the pollutants from entering the creek, and how they would you their community involved in maintaining the healthy creeks and rivers. Ask them for ideas on how to educate others about the things that affect our creeks and rivers.

Activity Extensions

1. Invite a water quality scientist to visit your class to talk about what they do.
2. Students can take a pledge of doing three activities that reduce water pollution. Some choices include: help parents take their cars to a car wash that recycles its water (some coin-operated car washes also do this); pick up trash and dispose of it in a secure trashcan; tell adults that storm drains go directly to creeks and the ocean; carpool to reduce car usage; pass the word--share what they learn in school about water pollution with everyone they know!
3. As a class, join a volunteer water quality-monitoring group, such as the sanctuary’s group, and participate in Snapshot Day. Contact the Coastal Watershed Council to see if there are activities you can do as a group that will help your local waterways.

Story: Who polluted our creek?

The weather is changing. It begins to rain, and soil from a construction site washes into the local creek, which flows to the bay. (Stop the story and ask: What is soil washing into the creek called and why is it a problem? Erosion happens when rocks break down into sand, silt, and clay. When this washes into creeks, muddy water blocks sunlight that plants need to photosynthesize so they can grow. Plants are the basis of the food chain: no plants equals no food chain. And, muddy water clogs fish gills so they can't breathe.) As the storm gets worse, the wind blows leaves into the water. (Ask: Would you drink this water? Play in it? Is it safe for wildlife?)

High up in the Gabilan Mountains there is a mining operation. As miners remove rocks from the earth, acids seep into the creek. Next to the creek there is a house that has a septic tank containing waste-water from the house. The homeowner doesn't know it, but there is a leak in the tank and untreated sewage is seeping into the creek. Down the dirt road, there is a cattle ranch that has many horses. The manure from these animals washes into the creek with the rain. (Ask: Now, would you drink the water? Would you play in it? Is it safe for the wildlife that lives in and around it?)

On the edge of the creek are agricultural fields. The farmers use chemical pesticides on their crops to keep bugs away, and a chemical fertilizer to help their plants grow faster. Every time it rains, some of these poisons wash into the creek. Downstream, the river runs through our town. The rain carries garbage from the streets and parking lots to the storm drains, which flow into our creek. People drive to and from work everyday. Their cars leak small amounts of oil into the street. With each rain, the oil runs down the storm drains and into the creek. The exhaust from these cars goes into the air as a colorless gas called carbon monoxide. These gases combine with moisture in the air to form acid rain. Some of the city people work in a factory, where smog from the smokestacks also adds to the acid rain problem. At a home, a father is teaching his daughter to tune up the family car. They pour the used motor oil and antifreeze down the storm drain not knowing that it runs right into their creek. Across the street, the neighbors are washing their car. The soapy water runs down the curb and into the storm drain as well. (Ask: Would you want to drink this water? Swim in it? Canoe in it?)

Story: Who polluted our creek?

LESSON 3.3

It is the weekend, and families and friends are having parties in the park next to the creek. As it begins to rain, they run for their cars, and don't pick up their trash and nasty cigarette butts. The rain carries all that trash right into the creek. As the wind picks up, several balloons break loose from the local car dealership. As the balloons lose their helium, some land on the streets. The flat balloons get carried along with the storm runoff, and wash into the creek. Just a few miles down the creek, a man dumps his old refrigerator and car tires along the side of the creek. He is too cheap to pay the small fees at the solid waste treatment facility. (Ask: Would you want to drink this water? Swim in it? Be an animal that has no choice but to live in it or drink from it?)

Further downstream, near the beach, there is an old military base. Harmful chemicals such as PCB's were used in the 1950's during experiments. Some of these chemicals are still in the soil, so when it rains they are washed into the creek. PCB's accumulate in animal tissue and can produce disease or death.

Now, look at your local creek! Can we swim in it? Play in it? Eat fish from it? Are the animals that live in and around it healthy? What about the ocean? What should we do? How can we help? Whose job is it to fix this problem?

Water Quality Datasheet

Contaminación de Aguas Subterráneas

Water Quality Field Data Sheet

Date
Time
City
Location Name
Water Body type (lake, creek, etc)

Team Members

1	4
2	5
3	6

Water Clarity (circle one):
Clear; Cloudy; Turbid;

Water Flow Rate (circle one):
Stagnant; Trickle (< 1 quart/sec); Normal (< 5 gal/sec); High (> 5 gal/sec);

Weather Conditions (circle one):
clear; cloudy; foggy; misty; calm; partly cloudy; breezy; rainy; windy;

Sample Collection:

	Results / Units(circle)	Taken by	Time	Ranking (good, fair, poor)
Air Temp	F or C			
H2O Temp	F or C			
pH				
Dissolved Oxygen	ppm			
Turbidity	JTU			

Notes: (include any observations, ie. types of trash, types of animals and plants, human impacts, etc.)

Water Quality Datasheet

Contaminación de Aguas Subterráneas

Water Quality Field Data Sheet

Date
Time
City
Location Name
Water Body type (lake, creek, etc)

Team Members

1	4
2	5
3	6

Water Clarity (circle one):
Clear; Cloudy; Turbid;

Water Flow Rate (circle one):
Stagnant; Trickle (< 1 quart/sec); Normal (< 5 gal/sec); High (> 5 gal/sec);

Weather Conditions (circle one):
clear; cloudy; foggy; misty; calm; partly cloudy; breezy; rainy; windy;

Sample Collection:

	Results / Units(circle)	Taken by	Time	Ranking	(good, fair, poor)
Air Temp	F or C				
H20 Temp	F or C				
pH					
Dissolved Oxygen	ppm				
Turbidity	JTU				

Notes: (include any observations, ie. types of trash, types of animals and plants, human impacts, etc.)

Dissolved Oxygen Instructions

Instrucciones para Oxigeno Disuelto

1. Submerge the small tube into the water sample and fill up to the top.
   Sumerge el tubo pequeño en la muestra de agua y llena lo con agua hasta arriba.

2 Drop both "Dissolve Oxygen TesTabs" into the tube (read the label before opening).
   Agrega 2 pastillas de "Dissolve Oxygen" en el tubito (lee la pastilla antes de abrirla).

3. Screw the top onto the tube and shake it until the pills have dissolved.
   Ponle la tapa al tubito y mezclalo hasta que las pastillas se disuelvan.

4. Wait 5 minutes for the color of the water to develop.
   Espera 5 minutos para que se desarrolle un color en el agua.

5 Compare the color of the water to color chart that your teacher has.
   Compara el color del agua con los colores de la tarjeta que tiene la maestra.

6 Locate the temperature of the water sample on the Percent Saturation chart (below). Locate the dissolved oxygen result of the sample at the top of the chart. The percent saturation of the water sample is where the temperature row and dissolved oxygen column intersect.
   Localiza la temperatura de la muestra de agua en la tabla de Porcentaje de Saturación (debajo). Localiza el resultado del oxigeno disuelto en la parte de arriba de la tabla. El lugar donde la temperatura y el oxigeno disuelto se juntan, es el porcentaje de saturación de la muestra de agua.

7. Write the results on your data sheet.
   Escribe el resultado en tu hoja de datos.

8. Give the water sample to the teacher to dispose. Do not return the water to the stream or lake.
   Dale la muestra de agua a la maestra para que la tire. No la regreses al rio o lago.

What is Dissolved Oxygen (DO)?
It is the amount of oxygen dissolved in water. DO concentration is reported in units of mg/l (milligrams per liter). mg/l is also referred to as parts per million (ppm) because a liter is 1000 grams of fresh water, and a milligram is a millionth of that. Percent saturation tells us what part of the water's holding capacity is actually used. When water holds all the dissolved oxygen it can at a given temperature, it is said to be 100% saturated with oxygen.

Percent Saturation Table

Temperature (0C)	Dissolved Oxygen		
	0ppm	4ppm	8ppm
2	0	24	48
4	0	26	51
6	0	27	53
8	0	28	56
10	0	29	59
12	0	31	61
14	0	32	65
16	0	34	67
18	0	35	70
20	0	37	73
22	0	38	76
24	0	40	79
26	0	41	82
28	0	42	85
30	0	44	88

Dissolved Oxygen Instructions

Instrucciones para Oxigeno Disuelto

Why is Dissolved Oxygen important?
Aquatic organisms need oxygen to survive and grow. Some species require high DO, such as trout and stoneflies. Other species do not require high DO, like catfish, worms and dragonflies. If there is not enough oxygen in the water, fish, insects, eggs and larvae may not survive. This leads to lowered diversity.

What affects the DO concentration in water?
Physical Factors affecting saturation:
- Temperature: As temperature increases, dissolved oxygen capacity decreases.
- Altitude: Water holds less oxygen at higher altitudes.
- Salinity/mineral content: As salinity or mineral content increases, dissolved oxygen capacity decreases, there is less "space" in the water for oxygen.

DO Sources (inputs - Oxygen is added to water)
- Re-aeration: Oxygen from the atmosphere is dissolved in water at its surface, mostly through turbulence (such as wave action, rapids, etc.)
- Photosynthesis (during daylight): Plants produce oxygen during photosynthesis.

DO Sinks (outputs - Dissolved oxygen removed from water)
- Respiration: Aquatic organisms breathe and use oxygen. Large amounts of oxygen are also consumed by decomposing bacteria (large amounts of dead material increase amount of bacteria). Examples: dead organic matter (i.e. algae, rotting plants), sewage, yard waste, oil and grease.
- Chemical Oxidation: Some oxidizing materials or rust naturally use oxygen.

What are generally the biggest causes of low DO?
Increases in water temperature, algal blooms, human waste (sewage, urban, agricultural runoff and industrial discharge) and animal waste.

What are the changes in aquatic life [when DO levels are low]?
Species that cannot tolerate low levels of dissolved oxygen—mayfly nymphs, stonefly nymphs, caddisfly larvae, and beetle larvae - will be replaced by pollution-tolerant organisms, such as worms and fly larvae. Algae and anaerobic organisms (that live without oxygen) may also become abundant in waters with low levels of dissolved oxygen. This causes major shifts in diversity of aquatic organisms.

What are acceptable ranges?

DO Results (% Saturation)	**Ranking**
91% - 110% Saturation	Excellent
71% - 90% Saturation	Good
51% - 70% Saturation	Fair
< 50% Saturation	Poor

pH Instructions

Instrucciones para pH (Hidrogeno potencial)

1. Submerge the bigger tube into the water sample and fill up to the top.
   Sumerge el tubo grande en la muestra de agua y llena lo con agua hasta arriba.

2. Drop 1 "pH Wide Range TesTab" into the tube (read the label before opening).
   Agrega 1 pastilla de "pH Wide Range" en el tubo (lee la pastilla antes de abrirla).

3. Screw the top on the tube and shake it until the pills have dissolved.
   Ponle la tapa al tubo y mezcla lo hasta que las pastillas se disuelvan.

4. Compare the color of the water to pH color chart.
   Compara el color del agua con los colores de la tarjeta del pH.

5. Write the results on your data sheet.
   Escribe el resultado en tu hoja de datos.

6. Give the water sample to the teacher to dispose. Do not return the water to the stream or lake.
   Dale la muestra de agua a la maestra para que la tire. No la regreses al rio o lago.

What are acceptable ranges?

pH Results	Ranking
5-8.5	Good
8.2-14	Poor
1-5	Poor

What is pH?
pH stands for potential hydrogen; it's a measurement of the acidic or basic quality of water. The pH scale ranges from a value of 0 (very acidic) to 14 (very basic), with 7 being neutral.

Why is pH important?
pH affects the chemistry of the water and the function of organisms. If the pH is too acidic or basic, the organism's growth and reproduction stops. Some species cannot survive with a pH less than 4. Most aquatic organisms are adapted to a specific pH level and may die if the pH changes even slightly.

How is it measured?
pH is measured through a variety of tests, commonly using pH tablets or pH litmus strips. It's a very common analysis of water quality testing. Since water contains both H+ (hydrogen) ions and OH-(hydroxyl) ions. The pH test measures the H+ concentration.

pH Instructions

Instrucciones para pH (Hidrogeno potencial)

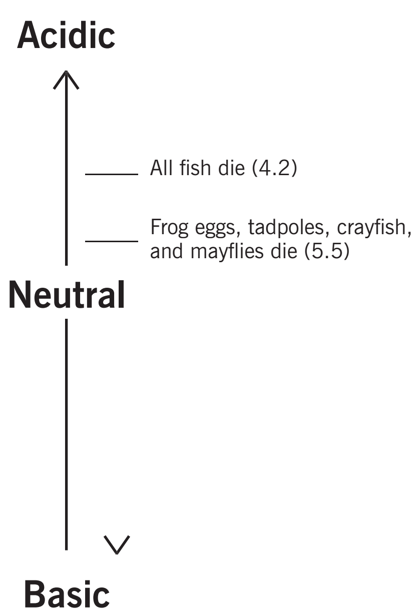
What factors affect it [pH]?

Natural Factors

- Rapidly growing algae and vegetation
- Removal of carbon dioxide during photosynthesis
- Acid rain or acid snow

Human Factors

- Industrial waste, agricultural runoff
- Drainage from improperly run mining operations
- Dumping of heavy metals like mercury or lead
- Increased amounts of sulfur and nitrogen oxides from automobiles and power plants



PH Level	Example:
1	Stomach or battery acid
2	Lemon juice
3	Vinegar, orange juice
4	Soda, acid rain
5	Clean rainwater, bananas
6	Milk, healthy lake
7	Drinking water
8	Eggs, seawater
9	Baking soda
10	Milk of magnesia
11	Ammonia
12	Soapy Water
13	Bleach
14	Liquid drain cleaner

Nitrate Instructions

Instrucciones para Nitrato

1. Submerge the bigger tube into the water sample and fill up to the 5mL line.
   Sumerge el tubo grande en la muestra de agua y llenalo con agua hasta la marca de 5mL.

2. Drop one "Nitrate Wide Range TesTabs" into the tube (read the label before opening).
   Agrega 1 pastilla de "Nitrate Wide Range TesTabs" en el tubito (lee la pastilla antes de abrirla).

3. Screw the top onto the tube and shake it until the pill dissolves.
   Ponle la tapa al tubito y mezclalo hasta que las pastilla se disuelva.

4. Wait 5 minutes for the red color to develop. If there's no color or it's yellow, record the results as 0ppm.
   Espera 5 minutos para que aparezca el color rojo. Sí el agua no cambia de color o esta amarillenta, apunta como resultado 0ppm.

5. Compare the color of the water to the nitrate color chart that your teacher has.
   Compara el color del agua con los colores de la tarjeta de nitrato que tiene la maestra.

6. Write the results on your data sheet.
   Escribe el resultado en tu hoja de datos.

7. Give the water sample to the teacher to dispose. Do not return the water to the stream or lake.
   Dale la muestra de agua a la maestra para que la tire. No la regreses al rio o lago.

What are acceptable ranges?

Nitrate Results	Ranking
5ppm	Fair
20ppm	Poor
40ppm	Poor

What is Nitrate?
Nitrate is a form of nitrogen, one of the most abundant elements. About 80 percent of the air we breathe is nitrogen. It is found in the cells of all living things and is a major component of proteins. Nitrogen exists in the environment in many forms. Nitrate is a nutrient needed by all aquatic plants and animals to build protein. It is measured in milligrams per liter (mg/L)

Nitrate Instructions

Instrucciones para Nitrato

Why is Nitrate important?

Nitrate reactions in fresh water can cause oxygen depletion. The decomposition of dead plant and animals, and the excretions of living animals release nitrated into the aquatic system.

What increases Nitrate concentrations in water?

- Leaking of septic systems or sewage treatment plants
- Organic waste - plant and animal decomposition
- Pet wastes – animals (particularly ducks and geese) that have direct access to waterways
- Industrial waste, agricultural runoff (fertilizers)
- Runoff from fertilized land- residential lawns, home gardens, golf courses

What are the changes in aquatic life when Nitrate levels are high?

- Increases plant growth and decay
- Promotes bacterial decomposition
- Decreases the amount of oxygen in the water

Phosphate Instructions

Instrucciones para Fosfato

1. Submerge the bigger tube into the water sample and fill up to the 10mL line.
   Sumerge el tubo grande en la muestra de agua y llenalo con agua hasta la marca de 10mL.

2. Drop one “Phosphorus TesTabs” into the tube (read the label before opening).
   Agrega 1 pastilla de “Phosphorus TesTabs” en el tubito (lee la pastilla antes de abrirla).

3. Screw the top onto the tube and shake it until the pill dissolves.
   Ponle la tapa al tubito y mezclalo hasta que las pastilla se disuelva.

4. Wait 5 minutes for the blue color to develop. If there’s no color, record the results as 0ppm.
   Espera 5 minutos para que aparezca el color azul. Sí el agua no cambia de color, apunta como resultado 0ppm.

5. Compare the color of the water to the phosphate color chart that your teacher has.
   Compara el color del agua con los colores de la tarjeta de fosfato que tiene la maestra.

6. Write the results on your data sheet.
   Escribe el resultado en tu hoja de datos.

7. Give the water sample to the teacher to dispose. Do not return the water to the stream or lake.
   Dale la muestra de agua a la maestra para que la tire. No la regreses al rio o lago.

What are acceptable ranges?

Nitrate Results	Ranking
1ppm	Excellent
2ppm	Good
4ppm	Fair

What is Phosphate?
Phosphate is a form of phosphorus, a nutrient required by all organisms. Phosphorus is a natural element found in rocks, soils and organic material.

Phosphate Instructions

Instrucciones para Fosfato

Why is Phosphate important?

Excess phosphorus in the water is a concern because it can stimulate the growth of algae. Excessive algae growth, death, and decay can severely deplete oxygen supply in rivers, endangering fish and other forms of aquatic life.

What increases Phosphate concentrations in water?

- Leaking of septic systems or sewage treatment plants
- Organic waste - plant and animal decomposition
- Pet wastes – animals (particularly ducks and geese) that have direct access to waterways
- Industrial waste, agricultural runoff (fertilizers)
- Runoff from fertilized land- residential lawns, home gardens, golf courses
- Detergents/soaps from washing cars on street

What are the changes in aquatic life when Phosphate levels are high?

- Increases plant growth and decay
- Promotes bacterial decomposition
- Decreases the amount of oxygen in the water

Temperature Instructions

Instrucciones para Temperatura

1. Make sure your container has a thermometer strip attached to it. Submerge the container into the creek or lake.
   Asegurate que tu bote tenga pegado la tira del termometro. Sumerge el bote debajo de la superficie del agua del arroyo o lago.

2. Hold the container from the top in the water for 1 minute.
   Agarra el bote de la parte de arriba y metelo en el agua por 1 minuto.

3. As soon as you remove your container, record the number that is highlighted on the thermometer on your data sheet.
   En cuanto saques el bote del agua, escribe el numero que resalte en la tira del termometro en la hoja de datos.

What are acceptable ranges?

Temperature Results	Ranking
$> 20^{o}$ C	Excellent
12^{o} C to 20^{o} C	Good
$< 20^{o}$ C	Poor

What is temperature?
Temperature is the degree of heat or cold of a body or environment. Temperature is a measure of the average kinetic energy of water molecules. It is commonly measured on a linear scale of degrees Celsius or degrees Fahrenheit.

Conversion from Celsius to Fahrenheit : $^{o}C = (^{o}F - 32) \times 5/9$.

Why is temperature important?
Temperature is one of the most important water quality parameters. Temperature affects water chemistry and the functions of aquatic organisms. It affects the:

- Amount of oxygen that can be dissolved in water,
- Rate of photosynthesis by algae and other aquatic plants,
- Metabolic rates of organisms,
- Sensitivity of organisms to toxic wastes, parasites and diseases,
- Timing of reproduction, slowing of metabolism, and migration of aquatic organisms.

Temperature Instructions

Instrucciones para Temperatura

What factors affect temperature?

Natural Factors

- Sunlight Energy: Seasonal and daily changes, shade, air temperature
- Color and turbidity of water: suspended sediment absorbs heat
- Water flow
- Depth of water: deeper water is usually colder
- Inflow of groundwater: Usually colder than stream
- Inflow of surface water into stream which is at a different temperature than the stream (Example: A drainage ditch or another stream)

Human Influence

- Removal of riparian vegetation, enabling direct sunlight
- Alterations to stream morphology (e.g., pool depth)
- Water diversions decreasing flow
- Accelerated soil erosion, increase in turbidity and heat absorption
- Increased storm water runoff
- Cooling water discharges from power plants

What are acceptable ranges?

Temperature Ranges (in º C)	**Examples of aquatic life**
Greater than 20º C (warm water)	Much plant life, bass, crappie, bluegill, carp, catfish, leeches, caddisfly
12º C to 20º C (Middle range)	Some plant life, trout, stonefly, mayfly, caddisfly, water beetles, sockeye salmon
Less than 12º C (Low range)	Trout, caddisfly, stonefly, mayflies

Turbidity Instructions

Instrucciones para Turbulencia

1. Find Secchi disk on the inside bottom of small bucket.
   Encuentra el secchi disk adentro de la cubetita blanca.

2. Fill bucket with water from the river or lake.
   Llena la cubetita con agua del rio o del lago.

3. Find the "Turbidity Chart' to refer to.
   Usa la tarjeta que dice "Turbidity."

4. Look down into your water sample and compare the color of the black and white circle inside the container to the one on the chart.
   Mira adentro de la muestra de agua y compara el color del circulo negro y blanco que esta dentro al circulo que esta en la tarjeta.

5. Pick the one that matches your sample and write the number on your sheet.
   Escoge el que sea igual al de tu muestra de agua y escribe el numero en tu hoja.

What are acceptable ranges?

Turbidity Results (JTU)	**Ranking**
0 JTU	Excellent
Between 0 & 40 JTU	Good
Between 40 & 100 JTU	Fair
> 100 JTU	Poor

What is turbidity?
Turbidity is a measure of how clear or cloudy water is. Algae, suspended sediment, and organic matter particles in the water can cloud it, making it more turbid. A secchi disc or a turbidity meter is used and the results are measured in feet or meters and converted to JTU (Jackson Turbidity Units) or NTU (Nephelometric Turbidity Units) – these are equivalent to JTU.

Why is turbidity important?
When there are suspended particles in the water, they diffuse sunlight and absorb heat. This can increase temperature and reduce light available for algal photosynthesis. Suspended sediments can clog the gills of fish. Once the sediment settles, it can foul gravel beds and smother fish eggs and benthic insects. The sediment can also carry pathogens, pollutants and excess nutrients.

Turbidity Instructions

Instrucciones para Turbulencia

What factors affect it?

Natural Factors

- Algae and nutrient loading
- Suspended sediment from erosion and sediment transport
- Seasonal weather, storm events
- Local stream morphology determines whether sediments are deposited or eroded

Human Factors

- Erosion due to removal of riparian vegetation, changes in stream morphology or stream flow patterns
- Excessive nutrient loading from agriculture and algal growth

What are expected turbidity levels?

Since the rivers, lakes, bays and ocean waters of California are home to small, suspended plants and animals called plankton, some amount of turbidity is natural. The level of turbidity will vary depending on nutrient loading, geology and stream dynamics. Here are some typical turbidity values for different water bodies.

Water Type	**Turbidity Level**
Drinking water	< 0.1 JTU
Typical Groundwater	< 1 JTU
Water bodies with moderate plant and animal life	1-10 JTU
Water bodies enriched with nutrients and large clouds of plankton	10-50 JTU
Water bodies with sparse plant or animal life	< 0.1 JTU
Winter storm flows in creeks and rivers	20-1000 JTU

Water Quality Monitoring

LESSON 3.4

Summary

Students take a field trip to learn about the water quality testing protocols scientists use by conducting their own water quality tests in a nearby stream in the fall and repeating the tests in the spring. Students conduct field tests for pH, turbidity, temperature, nitrates, phosphates, and dissolved oxygen, and look for invertebrate organisms that might reveal the health of the stream. They compare their results with past data taken by Sanctuary Water Quality Monitoring Programs, if available. Students evaluate their data and possible explanations of their results, and discuss how the data may be used to inform policies or changes regarding watershed protection.

Learning Objectives

Students will be able to:

- Follow procedures to conduct water quality tests for pH, nitrates, phosphates, temperature, turbidity, and dissolved oxygen
- Record data results from water quality tests
- Develop a hypothesis and collect data to inform the hypothesis
- List three water safety guidelines
- Make field observations of water quality

Background

The Monterey Bay National Marine Sanctuary has a mandate to protect resources in the Sanctuary from pollution. While some polluting activities are easy to detect and stop, one of the most difficult sources of pollution to identify and prevent is non-point source pollution—pollution coming from sources that cannot be directly located. Runoff, water that does not soak into the ground, can originate miles away in urban areas, agricultural land, construction sites, lawns, and some industries, such as mining. Polluted runoff can contain heavy metals, salts, sediment, nutrients, and bacteria. All of these can injure or kill wildlife, or severely alter the natural balance of marine communities.

In urban areas, pollutants from backyards and parking lots are carried during rainstorms into storm drains that flow directly into the ocean. Even cities miles from the coast are part of the watershed, and water from these cities enters storm drains that eventually follow gravity to the sea. The larger the population of people in a watershed, the more homes, businesses and industries there are to contribute polluted runoff water to a storm drain that eventually finds its way into the Monterey Bay National Marine Sanctuary. Many of our daily activities may contribute to non-point source pollution without our knowledge, including lawn and landscape maintenance, where excessive amounts of

Duration

60 minutes plus travel time to and from school

Teacher Prep

1. Do Lesson 3.3 Who Polluted Our Creek? to prepare students for their fieldtrip
2. Contact MERITO staff person for fieldtrip assistance (optional)
3. Photocopy Water Quality Data Sheets (one per group)
4. Photocopy Water Quality Instruction Sheets (one set per group)
5. Organize materials and kits for water quality sampling (See Lesson 3.3)

Water Quality Monitoring

LESSON 3.4

Vocabulary

Dissolved oxygen
Erosion
Nitrates
Pesticides
pH
Phosphates
Pollution
Runoff
Storm drain
Temperature
Turbidity
Water quality

Materials

- Water quality test kit (from science kit)
- Water Quality Data Sheets (one per group)
- Water Quality Instruction Sheets (one set per group)
- Waste bucket with lid (one gallon) (optional)
- Data from MBNMS Water Quality Monitoring Programs (if available for your test site)

pesticides and fertilizers may get washed into creeks. Changing the fluids in a car engine or oil leaks can leak petrochemicals into the environment. Construction projects like homes, highways and shopping malls can cause erosion and mud to flow into the ocean.

We can tell something about the health of the environment in an area like a watershed by checking its water quality. Several different water characteristics can be evaluated using general observations and simple chemistry. Six key water quality measurements are pH, turbidity, dissolved oxygen, temperature, phosphates, and nitrates and are described below. The worksheets attached to this lesson explain why these tests are important and how to evaluate samples for their health.

Scientists measure water quality in the same area over many different days, months, or years in order to completely understand all the characteristics of the water in a particular area. Good water quality promotes good watershed health and may increase the numbers and types of organisms found in a watershed and in the ocean.

Lesson 3.3, "Who Polluted Our Creek?" is a preparation for water quality monitoring in the field. Read the lesson carefully and practice the procedure before going on the field trip.

Activity Procedure

Getting Ready for your Field Investigations

1. Choose the site where you will be conducting your water quality tests. There are locations that are regularly tested, so if you choose one of these you will be able to compare results with other scientists and with data collected at different times of the year.

2. The day before your fieldtrip, tell students that they will be going to a creek that may be muddy. Wear shoes and clothes that can get wet and muddy, and dress in layers--they will be outside and the weather can be changeable. Refer to Appendix H, Trail Manners.
   Teacher Tip: Whenever you go out in the field it is a good opportunity to pick up trash when you see it, so be sure to bring along a large trash bag.

Water Sampling Tests

1. After arriving at the field site, break the class into four groups and tell them first they will make observations and record them, write a hypothesis, and then they will test the water.

2. Hand out Water Quality Data Sheets to each group. Go over the worksheets with the class. Ask students to look around their creek and write their observations on their worksheet. Ask them to make a hypothesis. Tell students: A hypotheses is a theory that explains what you see. Scientists make hypotheses and then test them to see if they are correct. Some sample hypotheses are:
   • The water quality in this creek will be poor because it is next to an agricultural field.
   • The water quality in this creek will be excellent because there is lots of water flowing by and I don't see any trash.
   • The temperature of this creek will be high because it is shallow and in the bright sun.

3. Tell students: After you have taken your sample, do not dump the contents of your test tube samples back into the creek or on the ground. Have students pour their test tube samples into a "Waste Bucket" with a lid or just collect all sample tubes and lids. Bring the waste bucket back to class, and pour the waste into a sink. Rinse all equipment before putting it away.

4. Give to each group
   a. three large test tubes
   b. one small test tube
   c. the appropriate amount of "TesTabs" (test tablets) for each water quality test (see Water Quality Instruction Sheets)

5. Tell each group to collect a water sample from the water body (stream, river, or lake) and follow the instructions for each measurement (i.e. dissolved oxygen, pH, nitrates, and phosphates). Teacher tip: if necessary, collect one big sample in a bucket, and students can fill their test tubes from the bucket.

6. Tell students they must record their data on the Water Quality Data Sheets, as they are conducting their test, not afterwards. Remind students again to dispose of their test tube contents into the waste bucket, not on the ground or in the water, or to just hand them to you. The chemicals in the test tubes could harm aquatic life.

Journal Prompt Closing Activity

Tell students: Today we are testing the health of this water using scientific tools of measurement. These same tests are done across the nation by all kinds of people, from other students, to scientists, to citizens of the community. We are one part of a huge effort to watch the health of water in watersheds everywhere. If the water quality is poor, plants and animals (including us!) that depend upon the water will suffer. The data we collect can help us find out why, and what changes our community needs to make to improve its water quality. We will be returning to this same spot later in the year to see the changes the area and its water quality go through during different seasons. This is what we call monitoring. Keep your eyes and ears open, and be ready to observe and make predictions about what you see. Discuss how the data may be used to inform policies or changes regarding watershed protection.

Activity Extensions

1. Water Quality Testing Part II: During another season, revisit the same spot and follow the same instructions. Compare your results.
2. If a trip to a local body of water is not possible, this activity may be adapted as an in-class activity. The instructor/ leader may collect water samples from various locations and bring them to class for testing.
3. The test kits in the watershed science kit provide students with an overall understanding of why water quality monitoring is conducted, the types of tests involved, and what the tests measure. If your students are interested in taking part in more in-depth, ongoing water quality monitoring projects, you may contact the Citizen Watershed Monitoring Network. This network uses highly standardized protocols to ensure data accuracy.

7. For the temperature and turbidity measurements, groups share and rotate the large white water quality container with the thermometer strip and the secchi disk sticker. Students follow the instructions on the Water Quality Instruction Sheet.

8. Once students have completed all the tests, ask groups to briefly share and compare their results. Discuss the results and the overall health of the creek, and how their hypotheses held up.

9. Wrap-up. Back in class, compare and discuss your findings with those of the MBNMS Water Quality Monitoring Program of your site (if data is available). Ask students: How is our test going to make a difference? Why do scientists want tests from different water sources?

10. Keep all data sheets for comparison to other creeks or to repeat the water quality testing at the same spot during another season.

Adapted from "National Water Monitoring Day Field Data Sheet" MBNMS Citizen Watershed Monitoring Network.

Water Bug Detectives

LESSON 3.5

Summary

How can bugs tell us about the health of a stream? Students learn how to assess the water quality of a creek by studying its invertebrate life. Some of these invertebrates can tolerate higher levels of pollution, while others are "bugged" by it. Students use an identification key to identify different macroinvertebrates (bugs) and their pollution sensitivity level, then calculate how the creek rates on a relative pollution scale.

Learning Objectives

- Identify three macroinvertebrates that live in water
- List one macroinvertebrate that is in each pollution tolerance group: insensitive, moderately sensitive, or extremely sensitive
- Know how to collect macroinvertebrates without harming them—respect the bugs!
- Understand the significance of finding different kinds of bugs in our streams

Background

Scientists study not only water quality to determine whether a watershed is healthy, they also look at the presence and amount of fresh water invertebrates. Some of these invertebrates are tolerant to higher levels of pollution, while others are sensitive to pollution. By assessing the type and amount of invertebrates, scientists can make inferences about the amount of pollution in a stream, its overall water quality and the health of a watershed.

Activity Procedure

1. Prepare the students for a class field trip to the creek by reviewing behavior and safety protocols (see Appendix H, Trail Manners). Discuss what bugs are – they are invertebrates (animals without a backbone), and usually have 6 legs. Some bugs live in the water, while others move around on the surface of the water. Like all living things, water bugs need to eat, and are eaten by other animals. Water is their habitat—and if the water is polluted, they can't live there. Some bugs that live in water are more tolerant to water pollution than others. To find out how polluted a creek might be, scientists investigate the kinds and amounts of bugs in the water.

2. Once arriving at the sampling location, break students into groups of four. Hand out a Water Bug Detectives Data Sheet, bug nets, magnifying boxes, and clear containers to each group. Go over the data sheet with the class, and ask students to look around the creek and write their observations on their worksheet. Look around for various clues to creek health (Trash? Foam? Oil sheen? Clear running water?). How does the water look? (brown, muddy, green, clear, oil sheen, etc.) How high is it? (barely a trickle, rushing quickly, slow and meandering, etc.). Look for birds and watch to see if they are eating bugs.

Duration
60 minutes plus travel time to and from school

Teacher Prep
1. Read activity background
2. Locate a stream or water body near your school. If you need assistance, contact MERITO staff.
3. Arrange for field trip assistance if needed; decide if you can walk or need to drive to a nearby creek.
4. Photocopy Water Bug Detective Data Sheets, one for each group of four
5. Review field procedures.
6. Gather materials for each group

Materials
For each group of four students:
- Water Bug Detective Data Sheets
- Bug nets (from science kit)
- Magnifying boxes (from science kit)
- Clear large bowl or container for each group

Vocabulary
Invertebrate
Monitoring
Sensitive
Tolerant

Journal Prompt Closing Activity

Back in the classroom, students may use the ID cards to choose the most interesting insect they saw today. They will draw it as carefully as possible, including all details such as number of legs and the mouth. Label it according to the ID card, and specify what level of pollution tolerance it has (sensitive, tolerant, or somewhat sensitive). Was it common or uncommon in their sample? What does this tell them about their creek? Have students include their group's hypothesis and whether the data proved or disproved it.

Activity Extensions

As a class, decide the water quality of your creek based on your macroinvertebrate data. Then look at a map of your stream or body of water to see where the water comes from. Are there any likely sources of pollution that feed into your stream? Erosion and sedimentation is also a form of pollution. Is there anything that could be done to decrease the amount of pollution entering your stream? Contact your local water quality agency to see if you can help the community to decrease the amount of pollution entering your stream.

3. Demonstrate how to use the bug nets to look for invertebrates in the creek, and how to place them gently in the bowl with water for better viewing. Explain that aquatic macroinvertebrates are specialized to live in specific habitats. Some invertebrates will be swimming in the water, some will be on top, and others will be under rocks and between plants.

4. Position the groups about 10-15 feet away from each other, then tell students to begin to sample the water for invertebrates. They will have 25 to 30 minutes to explore and collect water invertebrates. Tell students: Your group goal is to collect as many different kinds of insects as you can find and not many insects of the same kind. Walk between groups to answer questions and ensure they are treating the invertebrates with respect.

5. Ask students to look at the insects on the back of the data sheets, and see if they can identify any of their bugs. Have students look at the identification cards and see if the bugs they have seen are tolerant of pollution. After collecting and identifying the insects, tally them on the data sheet and follow the instructions.

6. Once all groups have their results, each may share their results and conclusion on the overall health of the water body. Did they all agree? What could be some reasons for different results? (sampling location, sampling methods, etc.)

7. Tell students to carefully place the insects back where they found them.

Adapted from "Water Action Volunteers Monitoring Factsheets Series, 2003"
http://clean-water.uwex.edu/wav/monitoring/biotic

Water Bug Detectives Data Sheet

Detectives de Insectos de Agua

Date/*Fecha* ____________ Time/*Hora* ________ City/*Ciudad* ______________________________

Team members/ *Miembros del grupo* ____

____

Watershed and stream name/*Nombre de la cuenca y del río* ________________________________

Temperature of stream/*Temperatura del río* ____

Stream flow rate/ *Velocidad del agua* ___ High/*Rapida* ___ Normal/*Normal* ___ Low/*Despacio*

Water Clarity/*Claridad del agua* ___ Clear/*Transparente* ___ Cloudy/*Borrosa* ___Turbid/*Turbia*

Follow the instructions:
Sigue las instrucciones:

1. On the back of the page circle the insects found in each group.
   Al reverso de la hoja circula los insectos que encontraste en cada grupo.

2. Count the number of circled insects in each group and write that number in the box.
   Cuenta el numero de los insecto en cada grupo y escribe ese numero en la cajita.

3. Write your results in the area below and do the math:
   Escribe tus resultados en el área debajo y haz las cuentas:

Number of insects from group 1/*Numero de insectos del grupo 1*: _____ X 4 = _____
Number of insects from group 2/*Numero de insectos del grupo 2*: _____ X 3 = _____
Number of insects from group 3/*Numero de insectos del grupo 3*: _____ X 2 = _____
Number of insects from group 4/*Numero de insectos del grupo 4*: _____ X 1 = _____
Total Insects/*Insectos en total* (a) ____ Total Value/*Valor total* (b) ____

To find Index Score use this formula:
Para encontrar el Valor del Índice usa esta formula:

$$\frac{\text{Total Value/}\textit{Valor total}\text{ (b)}}{\text{Total Insects/}\textit{Insectos en total}\text{ (a)}} = \text{Index Score/}\textit{Valor del Índice}$$

Index Score / *Valor del Índice*

Index Score / *Valor del Índice*
Stream Health / *Salud del Río*

Excellent / Excelente... 3.6+
Good / Bien .... 2.6 – 3.5
Fair / Regular .... 2.1 – 2.5
Poor / Mala .... 1.0 – 2.0

Water Bug Detectives Data Sheet

Detectives de Insectos de Agua

Date/*Fecha* _____________ Time/*Hora* _________ City/*Ciudad*_________________________________

Team members/ *Miembros del grupo* ____

____

Watershed and stream name/*Nombre de la cuenca y del río* ___________________________________

Temperature of stream/*Temperatura del río* ____

Stream flow rate/ *Velocidad del agua* ___ High/*Rapida* ___ Normal/*Normal* ___ Low/*Despacio*

Water Clarity/*Claridad del agua* ___ Clear/*Transparente* ___ Cloudy/*Borrosa* ___Turbid/*Turbia*

Follow the instructions:
Sigue las instrucciones:

1. On the back of the page circle the insects found in each group.
   Al reverso de la hoja circula los insectos que encontraste en cada grupo.

2. Count the number of circled insects in each group and write that number in the box.
   Cuenta el numero de los insecto en cada grupo y escribe ese numero en la cajita.

3. Write your results in the area below and do the math:
   Escribe tus resultados en el área debajo y haz las cuentas:

Number of insects from group 1/*Numero de insectos del grupo 1*: _____ X 4 = _____
Number of insects from group 2/*Numero de insectos del grupo 2*: _____ X 3 = _____
Number of insects from group 3/*Numero de insectos del grupo 3*: _____ X 2 = _____
Number of insects from group 4/*Numero de insectos del grupo 4*: _____ X 1 = _____
Total Insects/*Insectos en total* (a) ____ Total Value/*Valor total* (b) ____

To find Index Score use this formula:
Para encontrar el Valor del Índice usa esta formula:

$$\frac{\text{Total Value/}\textit{Valor total}\text{ (b)}}{\text{Total Insects/}\textit{Insectos en total}\text{ (a)}} = \text{Index Score/}\textit{Valor del Índice}$$

Index Score / *Valor del Índice*

Index Score / *Valor del Índice* **Stream Health / *Salud del Río***	
Excellent / Excelente…	3.6+
Good / Bien …………	2.6 – 3.5
Fair / Regular ………	2.1 – 2.5
Poor / Mala …………	1.0 – 2.0

Visit a Wastewater Treatment Plant

LESSON 3.6

Summary

On a field trip to the City of Watsonville or Monterey County Waste Water Treatment Plant, students learn where wastewater goes, how it is treated, and how it is reused. In their visit, students fill out a questionnaire and see how natural organisms are used to decompose waste material in water.

Learning Objectives

Students will be able to:

- Define what waste water is, where it comes from and where it goes
- Describe how wastewater is treated and converted into re-usable water
- Explain how treated wastewater is used in this community

Background

Clean fresh water is precious and in short supply. Humans use a lot of water in their daily lives – through showering, doing laundry, going to the bathroom, washing dishes and cleaning. Water from homes and businesses flows into drains and collects in underground pipes. This water is not clean --- it contains solvents, cleaners, human waste, germs and dirt. If it got into the environment, it could be toxic to other living things and people.

Wastewater is defined as water that has been used in homes and businesses. Wastewater Treatment Plants collect wastewater from homes and businesses and clean it so it can be reused or safely released into the environment. They do this with the help of freshwater bacteria and other microorganisms that feed on human waste and decompose it into the basic elements of carbon, hydrogen, oxygen and nitrogen. These nutrients and the bacteria can then be removed from the water, leaving it nearly as clean as it once was. This reclaimed water can then be reused for irrigation, or released safely into local creeks or streams.

Because their wells were becoming contaminated with seawater, many Salinas Valley growers began watering their crops with recycled water from a nearby wastewater treatment plant. The goal of the water-recycling project is to reduce the extent of seawater intrusion, while providing local growers with a source of higher quality water for crops. An extensive study ultimately demonstrated that recycled water is as safe as well water when used to irrigate food crops. Near Salinas River State Beach and in other local areas, pipes colored purple near agricultural fields indicate recycled water is being used to water crops.

Duration

60 minutes plus
driving time to field trip site
30 minutes follow-up
after the field trip or
following day

Teacher Prep

1. Read activity background
2. Contact the City of Watsonville or Monterey County Waste Water Treatment Plant to schedule a field trip
3. Arrange for field trip transportation and chaperones
4. Photocopy Student worksheet, Visiting A Wastewater Treatment Plant

Vocabulary

Bacteria
Decompose
Microorganisms
Nutrients
Seawater intrusion
Wastewater
Wastewater treatment plant

Visit a Wastewater Treatment Plant

LESSON 3.6

Materials

- Field journals or handouts
- Student worksheet, *Visiting a Wastewater Treatment Plant*
- Other conservation materials available from the field trip site

Journal Prompt Closing Activity

Now that students have seen the great effort it takes to treat massive amounts of wastewater, remind them that wasting water sends it down the drain to the waste water facility. Ask them to come up with a slogan, poster, video or other educational product to help other understand why conserving water is so important.

Activity Extensions

There are many classroom activities available regarding water conservation and wastewater treatment. For free materials, check the California Department of Water Resources online catalog: http://www.publicaffairs.water.ca.gov/education/catalog.cfm

Activity Procedure

1. Contact the City of Watsonville or Monterey County Waste Water Treatment Plant to schedule a field trip. Arrange for field trip transportation and chaperones. See the Resources Section in the Appendices for contact information.

2. Review with students the proper etiquette for field trips.

3. Meet staff at the field trip site. Hand out the Wastewater Field Trip worksheet and tell them they need to fill it out on the trip (or use it as a follow-up activity). If they don't cover it in their talk, ask them: What is their job? Is it interesting? What did they study in high school and college to get this job?

4. Tour of the facilities. See how the facility moves the stages of treated water through different tanks. Point out to students how the plant captures methane gas to electrically power its operation. If you are touring the Monterey facility, have students look out over the agricultural fields nearby and point out that they are irrigated by treated wastewater.

Visiting a Water Treatment Plant

Visitando una Planta de Tratamiento de Aguas Negras

Name/Nombre ___________________________

What is the name of the Wastewater Treatment Plant you visited?
¿Cómo se llama la Planta de Tratamiento de Aguas Negras que visitaste?

What does a Wastewater Treatment Plant do?
¿Qué hace la Planta de Tratamiento de Aguas Negras?

What is Wastewater?
¿ Qué son las Aguas Negras?

From what cities does their wastewater come from?
¿De cuales ciudades vienen sus aguas negras?

How many wastewater gallons does this plant clean every day?
¿Cuántos galones de aguas negras limpian en esta planta de tratamiento?

What was the most interesting thing you learned on the field trip?
¿Qué fue lo mas interesante que aprendiste en este paseo?

Visiting a Water Treatment Plant Answer Key

Visitando una Planta de Tratamiento de Aguas Negras

LESSON 3.6

What is the name of the Wastewater Treatment Plant you visited?
Watsonville Wastewater Treatment Facility (other facilities will offer somewhat different answers). For information about other wastewater treatment plants, check their websites.

What Does a Wastewater Treatment Plant Do?
Collects wastewater from homes and businesses in a certain area and cleans it so it can be reused.

What is Wastewater?
Wastewater is defined as water that has been used in homes – from showering, bathing, washing dishes going to the bathroom, and laundry machines. Businesses and industries also produce wastewater – gymnasiums, laundromats, restaurants, etc. All this water is collected in drains and sent to a wastewater treatment plant for cleaning before it is released into the environment.

What is the size of the area the plant services?
21 Square miles, composed of City of Watsonville, Pajaro, Freedom, and Salsipuedes sanitary districts consisting of a population of 50,000.

How much wastewater does this plant clean every day?
The average daily flow is 7.0 million gallons per day!

What are the stages of wastewater treatment?
Stage 1: Collection. Water is collected through pipes and drains throughout the service area and delivered to the facility. The pipes are maintained to prevent leaks and clogs.

Stage 2: Treatment. The facility uses natural organisms in the water to clean it. Freshwater plankton, bacteria and other microorganisms feed on the nutrients in the wastewater, decomposing the waste. This cleans the water quite a bit. After the organisms have done their work, the water is treated to kill the organisms, and the remains (called biosolids) are removed.

Stage 3: Reclamation. The water is further cleaned to make it almost as clean as drinking water. It can them be re-used. It is either used for irrigation on fields, or released into a creek or stream to aid with water flow.

What was the most interesting thing you learned on the field trip?

Native Plant Garden

LESSON 3.7

Summary

In this year-long school project, students learn about native plants, propagate seeds, plant seedlings, record their growth and maintain a school garden throughout the year. In the process, students learn the basics of restoration ecology, habitat management, native plant species, and landscaping.

Learning Objectives

Students will be able to:

- Describe the difference between native and non-native plant species
- List the restoration activities that should be done in each season
- Create and maintain a healthy native plant habitat at their school site, being fully involved in the planning, design and planting of the garden
- Keep a Garden Journal that monitors the weekly development of the garden, and to record their reflections on their native garden experience

Background

Restoration ecology is the study of returning (restoring) a habitat to its native state. Native plant restoration efforts are crucial because invasive and non-native weeds are have expanded throughout California and most of the western United States. A non-native plant can be defined as a that is not indigenous to an area – it has been imported, usually from another country. Examples of non-native plants include Eucalyptus, a tree from Australia, yellow Mustard, a Mediterranean plant, and New Zealand spinach. An invasive species is one that displays rapid growth and spread, allowing it to establish rapidly over large areas, displacing native vegetation. Pampas Grass from Central America is an example of an invasive plant, as is German Ivy. Many invasive non-native weeds can evolve and adapt rapidly to the conditions of other habitats.

Invasive species compete with native plants for water, light, nutrients, and space. They also may reduce biodiversity, compete with threatened and endangered plant species, alter normal ecological processes (e.g. nutrient cycling, water cycling), decrease wildlife habitat, reduce recreational value, and increase soil erosion and stream sedimentation. Humans have introduced invasive non-native plants to North America either intentionally or incidentally over the last 150 years. Now, a movement to restore habitats to their native vegetation is gathering support in many communities.

The cycle of restoration is has different phases through each season. During the summer, seeds of native plants are collected and stored until they are ready to be planted. In the fall, seeds are sowed in trays and kept in a greenhouse until they are ready to be transplanted to the ground. This gives native plants a head start and helps them survive grazing (predation), competition with non-native plants, and harsh growing conditions

Duration

Two 60-90 minute class sessions per month; on average every other week, starting in the Fall and ending in Spring.

Teacher Prep

MERITO: Before you start your school garden, follow these tips to help make the job easier.

1. Communicate your plans with the school or site administrators to get approval in advance.
2. Contact a local native plant restoration organization for information and assistance.
3. Gather support from staff members, parents, local experts, and other volunteers.
4. Assemble tools, plants, gloves and mulch. Students may write letters to local businesses asking for donations of these items.
5. Have students develop garden journals

Native Plant Garden

LESSON 3.7

Materials
- School Garden
- A site for a garden
- Shovels
- Hand trowels
- Garden gloves
- Native plants or seeds
- Comfortable clothing and shoes
- Hose with fine spray nozzle
- Materials for garden art: paint, wooden stakes, rocks, etc.
- Art supplies for waterproof signs and garden art projects
- Recycled materials that work as garden art
- Garden Journals
- Garden Data Sheet

Cycle of Restoration Poster
- Student worksheet, Cycle of Restoration Poster
- Materials for making posters: Glue, tape, markers, crayons, scissors, poster paper (at least five pieces), previously pressed weeds and native plants (if available), glitter, props or pictures that represent the various signs for each season (i.e. weather, climate, restoration work, tools, plants)

Vocabulary
Introduced Species
Invasive
Native Plant
Non-native Plant
Restoration
Season
Seedling
Weed

(drought and heat). Planting of native seedlings begins in winter. The cooler temperatures and higher humidity in the winter are the best for transplanting. Once planted in their natural habitats, native seedlings can thrive on their own. To assure successful native plant restoration, weed out invasive and non-native weeds.

Planting a native plant garden helps restore native habitat and provides a seed source that can disperse to other areas. Gardens offer interdisciplinary teaching opportunities for all ages. Learning about water, native plants, beneficial insects and compost provides a portal for teaching science, literacy, math, nutrition, and personal skills such as leadership, problem-solving, and team building. School gardens and native plant restoration projects help instill community pride, build self-esteem, encourage physical activity, and may preserve cultural identity. A native plant garden also provides students with a service learning activity that offers them an opportunity to give back to their local community and environment.

Activity Procedure

Take a Walk On The School Grounds

1. Take your class on a walk on the school grounds. Look at the plants, shrubs and trees planted there. If possible, use a field guide to identify the plants. Start a discussion about native plants vs non-native plants. Native plants are naturally occurring in the habitat, while non-natives come from other places or countries. Ask your class how many of them have come here from other places or countries. They are non-natives too! We encourage people coming to the United States from other countries, and in the past we have embraced and planted many species from other countries. However, things have gotten out of balance. In some places, there are very few native plants. This makes it harder on wildlife, who need native plants for food, shelter and habitat. Announce to your class that you are going to start a native plant garden. While on your walk, find a good location on the school grounds to start a native plant garden (you may have already determined this spot). The first thing to do is find out more about what plants belong here and how to plant them, and get permission to plant a garden on school grounds.

2. Back in the classroom, write the schedule on the board:

   Fall Activities
   - Get permission from school to plant native garden
   - Find a source of native plants – nursery, seed catalog, or local organization (See Extensions)
   - Determine what species to plant and draw a landscape diagram
   - Start Garden Journals and/or data sheets
   - Clear site: remove non-native plants (weeds), rocks and trash, rake and smooth site.
   - Photograph starting site
   - Sow seeds in trays and cover in protected area or greenhouse; water weekly

Native Plant Garden

LESSON 3.7

Winter Activities
- Once seedlings are 1” tall, start planting
- Measure plant height weekly; water if necessary
- Photograph seedlings weekly

Spring Activities
- Continue to monitor and photograph weekly through spring
- Weed out non-native plants

3. **Start a Garden Journal**
Hand out materials for students to create and decorate the covers of their own Garden Journals. Students make entries as part of every School Garden activity, recording date, time, new vocabulary, weather, surroundings, changes, and other observations. The Garden Data Sheet may help your students better document changes to their seedlings over time, and can be used for graphing plant growth.

4. **Cycle of Restoration Poster**
Part of the ongoing project is to design a poster explaining the cycle of restoration. Divide the class into groups and direct them to design their own restoration poster. Distribute poster-making materials. Go over the Cycle of Restoration poster worksheet with students, offering suggestions.

Journal Prompt Closing Activity

Have students make entries in their garden journals each time they visit the garden. Be sure they describe what they have observed and learned. At the end of the school year, put the garden journals on display in the principal’s office or auditorium, or during an Open House for the school.

Activity Extensions

Take a trip to your school’s closest restoration site sponsored by a local native plant restoration organization. The Elkhorn Slough National Estuarine Research Reserve (ESNERR), Return of the Natives (RON) from CSU Monterey Bay, and Watsonville Wetlands Watch conduct ongoing native plant/habitat restoration projects near wetlands or endangered areas. Restoration staff will meet your group, explain the differences between native and non-native plants, and how seeds are collected and germinated. Leaders will demonstrate to students how to treat and transplant plants into designated areas, and how to remove unwanted weeds.

Garden Data Sheet

Hoja De Datos Para El Jardin

Name of Seedling /*Nombre de la Plantita o Retoño*____

Date planted /*Fecha que se plantó* _________________________

Date *Fecha*	Height *Altura*	Number of Leaves *Numero de Hojas*	Description/ *Descripción*	Action *Acción*

Cycle of Restoration

Poster Making Tips

1. Label the cycle goals (i.e. weed removal, propagation, planting, etc.) that correspond with each season on separate sheets of poster paper.

2. Feature the weeds and native plants that are significant to a particular season.

3. Point out the times that are best for collecting seeds and propagating native plants.

4. Make note of the times and methods that are best for removing unwanted “weedy” plants.

5. Decorate your poster using different media. Include plant pressings, photographs, and drawings in the cycle. Be creative!

Fall—Weather: Windy, cool, with some warm days
What we can do:
- Sow native plant seeds in greenhouses.
- Prepare soil for planting and propagation.
- Pampas grass is a late bloomer. Clip seed heads before the seeds spread.

Winter—Weather: Rainy, wet, and cold. Rarely snows. Fields are green from the rains.
What we can do:
- Plant native plants so they will become well established with winter rain. People can participate in restoration activities sponsored by Elkhorn Slough National Estuarine Research Reserve, the Return of the Natives, Watsonville Wetlands Watch, and the California Native Plant Society.
- Pull iceplant. It is easier when the ground is wet.

Spring—Weather: Rainy, sunny, cool
What we can do:
- The native plants are flowering. Make plant pressings of flowers. Take pictures.
- Make room for native plants—clear out invasive plants before they can flower and go to seed and increase the seedbank.
- Some weeds to watch out for are hemlock, milk thistle, and French broom.

Summer—Weather: Dry, sunny, warm, some fog and wind
What we can do:
- Native plants have produced seeds. Collect native seeds for fall sowing in the greenhouse.
- Remove weeds that are going to seed, to prevent future weeds.

Storm Drain Stenciling

LESSON 3.8

Summary

MERITO staff lead students in performing a community service by stenciling neighborhood storm drains and participating in a neighborhood cleanup.

Learning Objectives

Students will be able to:

- Understand how neighborhood storm drains lead to creeks, waterways, and the ocean
- Describe how substances poured down storm drains cause water pollution
- Develop pride in their neighborhood and stewardship for their environment

Background

Surface waters from eleven major watersheds drain over 7,000 square miles into the Monterey Bay National Marine Sanctuary. In cities and towns, much of this water goes through thousands of storm drain inlets in our neighborhoods. Everything that goes down storm drains flows directly into creeks, waterways, and the Monterey Bay National Marine Sanctuary. When motor oil, antifreeze, paints, fertilizers, pesticides, trash, and household chemicals are poured onto streets or down neighborhood storm drains, it creates storm drain pollution. The plants and animals that live in the creeks, rivers, and ocean are harmed by this pollution.

Unlike water that comes from homes and businesses, water from storm drains does not go to wastewater treatment plants. Even if we live miles from the Sanctuary, we can contribute harmful pollutants to coastal waters. Storm drain stenciling, painting a slogan next to the storm drain, is a public service that reminds people where the storm drains go. If they know where storm drains lead, people may think twice before dumping toxic materials, and by their actions can reduce the amount of pollutants entering the Sanctuary.

Duration

90 minutes plus travel time to and from the site

Teacher Prep

1. Contact MERITO staff to arrange storm drain stenciling
2. Photocopy Promise Cards, one per student
3. Tell students the day before the field trip to wear old clothes that can get paint on them and good shoes for walking. Bring garden gloves if they have them, to pick up garbage.

Materials

- Storm drain stenciling materials (provided by MERITO staff)
- Promise Cards (included in lesson)

Vocabulary

Runoff
Storm drain
Water pollution
Watershed

Storm Drain Stenciling

LESSON 3.8

Journal Prompt Closing Activity

After the activity, meet with your class for a short follow-up. How did they feel doing the stenciling? Was it fun? Would they do it again? Did they feel proud of performing an important public service? As a follow-up, you may want to use the attached "promise" cards for students to fill out and take home or display in class.

Activity Extensions

To further reduce the amount of garbage and toxic substances that enter the Sanctuary, your class can participate in the Sanctuary's Snapshot Day and First Flush, and the Coastal Commission's Coastal Cleanup Day. See the Contact List in the Appendices for contact information

Activity Procedure

Storm drain stenciling with MERITO staff

1. Contact MERITO staff to arrange a date for storm drain stenciling.

2. On the day scheduled for storm drain stenciling, read the Background section of this lesson to students so they understand that they will be performing an important public service by placing reminders on storm drains in the community.

3. Review safety and etiquette guidelines for walking around the community. All students should wear gloves and a red vest for safety purposes. These are provided by MERITO staff and must be worn by all participants.

4. Place students into groups with 4 to 6 students per group. Students will rotate through the following roles:
   a. Student with map
   b. Sweeper
   c. Student with tape
   d. Student with white paint
   e. Student with wet paint sign
   f. Student with spray paint
   g. Student with stencil
   h. Student with weights
   i. Students with trash bag
   j. Students with recyclables
   k. Student with cart

5. Using a street map, staff will show students what storm drains will be stenciled or re-stenciled, and the route you will take during the activity. Hand out street maps to each group and begin walking to your first storm drain.

6. When your group arrives at the first storm drain, listen to instructions from MERITO staff and watch the demonstration.

7. Students read the map to guide the group to the next storm drain. Students continue with the stenciling following the procedures demonstrated earlier.

Neighborhood clean up during storm drain stenciling

8. Talk to students about the importance of doing a neighborhood clean up. Emphasize that this is our community, our environment. Everyone in our community is responsible for working together to maintain a clean and healthy neighborhood. Talk to students about how they can become proud of their neighborhood, stewards of the community, and how they can lead the way to protecting and improving their environment. Give students trash and recycling bags to pick up trash while they travel through the neighborhood stenciling storm drains. Deposit the bags in the proper containers when you return to school.

Promise Cards

Healthy Land, Ocean, and Air for all Life!
Tierra, Océano, y Aire Limpio para todos los Seres Vivos!

I value our land and ocean because…
Yo aprecio nuestra tierra y el océano porque…

My biggest concern is…
Lo que me preocupa más es…

Something I promise to do to help keep the land, ocean, and air healthy is…
Algo que prometo hacer para ayudar a mantener la tierra, el océano y el aire limpio es…

Promise Cards

Healthy Land, Ocean, and Air for all Life!
Tierra, Océano, y Aire Limpio para todos los Seres Vivos!

I value our land and ocean because…
Yo aprecio nuestra tierra y el océano porque…

My biggest concern is…
Lo que me preocupa más es…

Something I promise to do to help keep the land, ocean, and air healthy is…
Algo que prometo hacer para ayudar a mantener la tierra, el océano y el aire limpio es…

Where Does Our Garbage Go?

LESSON 3.9

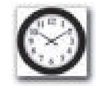
Summary
On a field trip to the local landfill, students learn where our garbage goes, how it is separated, recycled, or buried in the landfill, and what they can do to reduce the amount of garbage we create.

Learning Objectives
Students will be able to:
- Describe a landfill and its function as a repository for garbage
- Explain how garbage is separated, recycled or buried in the landfill
- List three reasons why it is important to recycle, reduce, and reuse
- Choose three ways they will work to reduce the amount of garbage their family creates at home

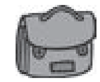
Background
Garbage or municipal human waste is collected from the curbs of homes and businesses and taken to a sanitary landfill. Like the name suggests, landfills are essentially large holes in the ground where garbage is dumped and stored. The more garbage we produce, the faster the landfill fills up with valuable natural resources. By reducing, re-using, and recycling, we can conserve natural resources for generations to come.

A trip to a modern sanitary landfill is fascinating, both because of the amount of garbage disposed there each day, but also because landfill engineers and staff work hard at keeping items out of the landfill. Besides the huge garbage disposal area, there are sites for recycling appliances and machinery, building supplies like concrete, and used tires. Another area accepts yard waste, called green waste, in a large compost area, converting the organic matter into mulch and potting soil. Another area processes all the items collected from curbside recycling programs. These items are sorted by type and trucked or shipped to recycling plants.

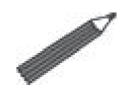
A trip to the landfill can be the start of a campaign by your class to change their own habits or those of friends and family. Encourage students to think of things they can do to reduce, reuse or recycle.



Duration
60 minutes, plus travel time



Teacher Prep
1. Read activity background
2. Contact local land fill to arrange field trip
3. Arrange for transportation and chaperones



Vocabulary
Compost
Garbage
Municipal Waste
Recycle
Reduce
Reuse
Sanitary Landfill

Journal Prompt Closing Activity

Ask students to draw a picture of what they saw at the landfill. Suggest ways they can reduce the amount of garbage coming from their home. Some suggestions include:

- Reuse bags from grocery stores, or better yet, use cloth bags that are reusable
- Use reusable containers for school lunches
- Buy products in bulk to reduce packaging
- Purchase the items with minimal packaging
- Recycle all glass, plastic, and aluminum containers
- Compost kitchen scraps
- Reuse bottles and containers before recycling
- Turn your trash into treasures by making trash art (http://www.kid-at-art.com/htdoc/product.html)

Activity Extensions

To learn more about reducing wastes and saving resources, your students can become members of the U.S. Environmental Protection Agency's Planet Protectors club. Online activities and http://www.epa.gov/epaoswer/osw/kids/

Activity Procedure

1. To schedule a field trip, contact a landfill near your school. See Appendix Q for local contact information.
2. Arrange for field trip transportation and chaperones.
3. Review with students the proper etiquette for field trips.
4. Meet the landfill staff at the field trip site. Be sure to ask them: What is their job? Is it interesting? What did they study in high school and college to get this job?

Teacher Tip: Also on the EPA website is "Be Waste Aware," a publication for students, with waste reduction resources, tools, activities, and ideas they can do in their community. http://www.epa.gov/epaoswer/education/pdfs/resource.pdf

Locally, Ecology Action (http://www.ecoact.org/) has a Waste Free Schools Program that assists Santa Cruz County schools in institutionalizing on campus recycling, composting and reducing / reusing programs while instilling in the students and school staff a sense of environmental stewardship. Check them out (www.wastefreeschools.org) and turn your school into a Waste Free School!

Check out "Away With School Waste," a guide designed for teachers interested in starting a school-wide waste reduction program at their schools. The guide was produced by Ecology Action, Life Lab Science Program, and the Santa Cruz County Office of Education, based on several years experience as partners managing and running the WFS. http://www.waste-freeschools.org/away_with_waste.html

Your class can participate in the California Coastal Commission's Coastal Cleanup Day (http://www.coastal.ca.gov/publiced/ccd/ccd.html)

What is a Wetland?

LESSON 4.1

Summary

Students observe a teacher demonstrate a model of a wetland and learn about the different functions of wetlands. Using similes, they explain some of the many functions or "jobs" of wetlands and gain an appreciation for their important role in the ecosystem. Both activities can be done as teacher demonstrations or in small groups.

Learning Objectives

Students will be able to:

- Identify water as the dominant feature that controls the plants and animals that live in wetlands
- Understand three functions or "jobs" that wetlands play in the ecosystem
- Use similes to compare household tools to wetland functions

Background

Wetlands are areas characterized by the presence of water, soils saturated with water, and special plants that are adapted to grow in soil that is filled with water. Wetlands are usually located between a body of water and land. Swamps, marshes, ponds, sloughs, bogs and estuaries are all examples of types of wetlands.

Wetlands are highly productive communities that play an important role in nature. Covering less than seven percent of the earth's surface; wetlands generate almost 25 percent of all productivity on earth. Wetlands perform important functions in the ecosystem, much like people perform important jobs or duties in society, or tools assist us in maintaining our homes.

Copyright.

They serve a particular purpose or role in keeping nature in balance. Wetlands help slow erosion, the washing away of soil from storm water runoff, ice, or wave action. Wetlands can act as natural filters by trapping pollutants and removing sediments from runoff. Wetland plants take up pollutants, breaking them into elements that can be used by the plants. Other pollutants get incorporated into the soil and are chemically neutralized through reactions occurring there. Where water moves slowly

Duration

Make a Working Wetland: 30 minutes
Introduction to Wetlands: 30 minutes

Teacher Prep

1. Read activity background
2. Gather materials
3. Photocopy Wetland Job Descriptions worksheet and cut into strips

Materials

- Wetland Job Descriptions worksheet
- Tools for similes:
  - kitchen strainer
  - sponge
  - funnel
  - coffee filter
  - baby bottle
  - jar containing muddy water
  - brush
  - rice or cranberries
  - bird feeder
  - soap
  - picture of a home
  - picture of a hotel
  - picture of shrimp or crab
  - binoculars

What is a Wetland?

LESSON 4.1

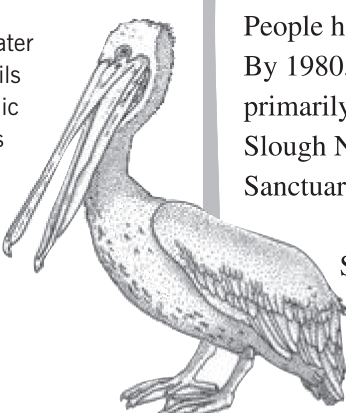
Materials

For Wetland Model demonstration:

- One aluminum sheet cake pan (13" x 9") or roller paint pan
- One lump of modeling clay
- Small piece of indoor/ outdoor carpeting, florists' "Oasis" foam, or sponge (to fit width of pan)
- Spray bottle with water
- Jar of muddy water (make sure there are some solid pieces in it, either small gravel or bits of sticks)

Vocabulary

Brackish
Community
Erosion
Filter
Function
Groundwater
Hydric soils
Hydrophilic
Pollutants
Runoff
Saturated
Wetland



through wetlands, plants slow the speed of the water and sediment falls to the bottom. This slow movement of water through wetlands also allows water to seep into the ground below. This helps increase the amount of groundwater stored underneath the land.

The water and soil support an abundance of hydrophilic (water-loving) plants, many of which leave dead and decaying leaves, roots and stems. Bacteria and zooplankton feed on the dead plant material, in turn providing abundant food for animals living higher up the food chain. Wetlands provide homes, places of refuge, or places to reproduce to an amazing array of creatures.

Copyright.

Some organisms live in wetlands year-round; many are seasonal visitors. They provide shelter and food for resident and migrating fish and bird species, and provide nursery habitat for 75-90 percent of fish and shellfish harvested in the United States. Wetlands are important to people too. Almost 95 percent of all fish or shellfish eaten by people depend on wetlands at some point during their life cycle.

Wetlands don't get much respect — often they are drained, filled in, and built upon. People have drained wetlands so that the land can be developed for building or agriculture. By 1980, over 115 million acres of wetland habitat in the United States had been lost, primarily to draining. In California, over 90 percent of wetlands have been lost. Elkhorn Slough National Estuarine Research Reserve, a part of the Monterey Bay National Marine Sanctuary, is one of just a few coastal wetlands remaining in California.

Similes are word comparisons that show how two different things are similar in one important way. Similes use the words "as" or "like" to make the connection between the two things being compared. Comparing an unfamiliar animal or plant adaptation to something that students are familiar with helps to build understanding. See more about similes in Activity 2.2.

What is a Wetland?

LESSON 4.1

Activity Procedure

Make a Working Wetland

Teacher Tip: If you have sufficient time and materials, this is an excellent activity for students to do in small groups. It is described here as a teacher demonstration.

1. Spread a layer of modeling clay in one half of the aluminum pan to represent land. Shape the clay to gradually slope down to the water (the other half of the pan. Smooth it along the sides of the pan to seal the edges. With a blunt narrow object (such as a popsicle stick), make meandering streams in the clay (representing the watershed) leading to the water. Cut indoor-outdoor carpet, sponge, or florists foam (this is the wetland) to fill the space across the pan along the edge of the clay. The clay and carpet together take up approximately two-thirds of the pan. Teacher Tip: make sure the carpet and clay make a snug fit in the pan—the model won’t work if there are large spaces under the wetland or between it and the sides of the pan.
2. Start the demonstration with the wetland out of the pan. Ask students to predict what they think will happen — the water will flow over the clay (land) into the ocean (pan). After they make their predictions, have one student pour water on the clay and observe the results. Pour the water out of the model.
3. Now put the wetland into the pan snugly against the clay. Ask students to predict what they think will happen this time. After they make their predictions, have one student pour water on the clay. Students observe and comment on what they see—some of the water is slowed down by the wetland, and excess water slowly flows into the ocean. Take the “wetland” out of the pan and squeeze the water out of it. Point out that the wetland absorbed the water and slowed it down.
4. Ask students: If a wetland is drained, and filled with soil, and houses are built on the filled-in soil, what might happen to the houses in a big storm? The houses might be flooded because the wetland will not be there to absorb and slow the rush of water from higher ground.
5. Shake the jar with water and mud thoroughly, and ask students to predict what they think will happen when muddy water is poured over the wetland. Pour the muddy water onto the clay. Some of the soil particles were caught in the sponge, and the water that passed through should be a little clearer. Tell students: Wetlands can trap soil and sediment and keep them from entering the ocean. The thick mat of plant roots traps silt and filters out pollutants, just as the carpeting did in this model.
6. Using the remainder of the clay, cover the “wetland.” Ask students to predict what they think will happen if wetlands are filled in with soil? The function or job wetlands fill—preventing flooding, reducing erosion and pollution of the ocean—will not be done. The result is an increase of these problems. This can affect the survival of many species as well as the quality of human lives.

Journal Prompt Closing Activity

Have students draw a coastal wetland or inland wetland that includes plants and animals. Ask students to include a title and some of the jobs wetlands do.

Activity Extensions

For an excellent poster, field guide, and I Spy activity you can download from the web or order online, check out http://www.mbayaq.org/PDF_files/activities/aquarium_wetlands_poster.pdf

Copyright.

What is a Wetland?

LESSON 4.1

Wetland Job Descriptions

Teacher Tip: This activity can be done as a demonstration/open discussion with the class, or the class can be divided into groups to develop their own comparisons.

1. There are seven "job descriptions" on the Wetlands Job Description worksheet. Cut these up so there is one job per slip of paper, and place them in a bowl or hat. Place the different tools on a table or at stations around the class.
2. Using the background information provided in this lesson, and after having seen how wetlands can affect the ecosystem from the demonstration, discuss wetlands and the important roles they play in keeping the ecosystem in balance. Use some of the tools on the table to make a comparison of the tool to a wetland function, or job. For example, a wetland filters pollutants like a coffee filter keeps coffee grounds from "polluting" coffee. The soil in the wetland acts as a filter, preventing some pollutants from getting into the soil or percolating down into groundwater.
3. Divide students into groups so each group gets one job. Have a student from each group pull a Job Description from the hat. Tell them to select an item or items from the tools provided and describe how this tool can be compared to a wetland function. Have them write a sentence on their worksheets comparing the tool to a wetland function, or job.
4. When everyone is finished, check for understanding by going around the class and asking students to read their comparisons aloud. Examples of other appropriate comparisons include: Wetlands are filters of pollutants, or "nature's sponge." They catch rainwater that drains from the land. Wetlands soak up pollutants as a sponge soaks up water (sponge). Wetlands filter sediments and mud out and lets clean water run through, like a coffee filter holds back coffee grounds and lets the coffee run through (coffee filter). Wetlands clean the environment of pollutants like soap cleans our hands of dirt (soap).
5. Wrap up the exercise with a summary of the important functions wetlands fulfill, and encourage students to develop a sense of protection and stewardship for them.

Wetland Job Descriptions

LESSON 4.1

1

Wetlands are filters of pollutants, or "nature's sponge." Wetlands catch runoff, rainwater that drains from the land. Wetlands can absorb pesticides, herbicides, and other contaminants that come from runoff before it reaches the ocean.

Tools:

Simile:

2

Wetlands are filters of nutrients that come from the agricultural fields such as nitrogen. If these nutrients stay in the water they harm the ocean or rivers, causing large amounts of algae to bloom that harm the plants and animals that live there.

Tools:

Simile:

3

Wetlands absorb so much water that they help control flooding. Wetlands soak up water from runoff during storms and slowly release the water into rivers and the ocean during the next few weeks.

Tools:

Simile:

4

Wetlands help slow erosion caused by rain. Erosion can cause rivers and the ocean to be muddy from all the sand and dirt coming in from the rain. When muddy runoff goes through a wetland, the plants slow the water and the dirt and sand fall out of the water.

Tools:

Simile:

5

Wetlands provide us with food. Cranberries and rice are grown in flooded plains, like wetlands. Crabs and shrimp grow in wetlands. Many fish and invertebrates need wetlands for part of their life cycle.

Tools:

Simile:

6

Wetlands give us many opportunities for recreation. We enjoy watching birds, photographing wildlife, hunting, and fishing. Swimming and boating are also popular activities.

Tools:

Simile:

7

Wetlands provide a home for thousands of birds, mammals, and other animals and plants. Some stay for the whole year, some visit seasonally. Almost half of all endangered species depend upon wetlands for survival.

Tools:

Simile:

Descripciones de Trabajos de los Pantanos

1

Los pantanos son filtradores de contaminantes, o son "la esponja de la naturaleza." Los pantanos atrapan las aguas lluvias que corren en la tierra. Los pantanos pueden absorber pesticidas, herbicidas, y otros contaminantes que recogen las aguas lluvias para que no entren al mar.
Herramientas:

Símil:

2

Los pantanos son filtradores de nutrientes que vienen de la agricultura, como el nitrógeno. Sí estos nutrientes se quedan en el agua pueden dañar a ríos o al mar, y causan que el agua se llene de algas marinas toxicas que lastiman a los animales y otras plantas que viven ahí.
Herramientas:

Símil:

3

Los pantanos absorben tanta agua que ayudan a controlar inundaciones. Los pantanos absorben el agua durante las lluvias y la dejan ir lentamente a ríos y al mar durante las próximas semanas después de la lluvia.
Herramientas:

Símil:

4

Los pantanos retrasan la erosión causada por las lluvias. La erosión puede causar que los ríos y el mar se haga borroso o sucio con tanto lodo. Cuando las aguas lluvias lodosas pasan por los pantanos, la arena y tierra se quedan atrapados en las plantas, para que no entre a los ríos o al mar.
Herramientas:

Símil:

5

Los pantanos nos dan comida. Las cranberries y el arroz crecen en lugares con mucho agua como los pantanos. Los cangrejos y camarones crecen en pantanos. Muchos invertebrados y peces también necesitan los pantanos por una temporada de su vida para crecer.
Herramientas:

Símil:

6

Los pantanos nos dan muchas oportunidades de recreación. Podemos disfrutar viendo muchos pájaros, tomar fotos a la vida salvaje, ir de pesca o de cacería. Nadar o andar en barco también son actividades populares en los pantanos.
Herramientas:

Símil:

7

Los pantanos son un hogar para miles de pájaros, mamíferos, y para otros animales y plantas. Unos animales viven en los pantanos toda su vida, y otros solo vienen por temporadas a visitar. Casi la mitad del las especies en peligro de extinción dependen de los pantanos para sobrevivir.
Herramientas:

Símil:

Wetlands Exploration

LESSON 4.2

Summary

Students take a guided field trip and are immersed in the rich ecosystems of local wetlands at the Elkhorn Slough National Estuarine Research Reserve or the Wetlands of Watsonville. Students conduct a scavenger hunt, learn how to be wetlands stewards and view first-hand the wonders of wetlands and the importance of their preservation and protection. As a part of the take home message, students gain a better understanding of the role of resource management agencies in conservation of local wetlands.

Learning Objectives

Students will be able to:

- Name and describe four organisms that live in wetlands
- Explain how a food web works and create a food web with three wetland organisms
- Name two native plants and two nonnative plants in the wetlands
- Demonstrate knowledge of how local wetlands connect to the Sanctuary
- Describe two ways they can help protect wetland habitats
- Record bird data, including identification and behavior (extension)

Background

Along the Central Coast of California, Elkhorn Slough National Estuarine Research Reserve and the Wetlands of Watsonville provide some of the last remaining wetlands habitat for people, animals, and plants.

Copyright.

Over the past 250 years, farming, drainage and irrigation projects, cattle grazing, and urban development have changed the Watsonville Wetlands. Only a portion of the former wetland system remains. Recognizing the value the wetlands provide for wildlife and for people, the community set aside remaining undeveloped wetland areas within the City of Watsonville for preservation and restoration. The Wetlands of Watsonville provide a resting stop for migrating birds. The wetlands also offer breeding habitat and year-round habitat for over 200 species of water bird, raptors and songbirds.

Duration

1.5 – 4 hours plus driving time from school.

Teacher Prep

1. Read activity background
2. To schedule a field trip to Elkhorn Slough, fill out the Field Trip request form (in Appendix) and send in at least three weeks in advance
3. To arrange a field trip to Watsonville Wetlands Nature Center, contact them at least three weeks in advance with your top preferred field trip dates, number of students and chaperones, and time of arrival
4. Arrange transportation and chaperones
5. Photocopy scavenger hunt worksheets, one per each group of two students

Materials

- For each pair of students, one copy of Elkhorn Slough Scavenger Hunt (Elkhorn Slough National Estuarine Research Reserve), or Wetland Scavenger Hunt (Watsonville Wetlands Nature Center)
- Clipboard and pencil for each pair of students

Wetlands Exploration

LESSON 4.2

Copyright.

Elkhorn Slough is the second largest salt marsh in California, second to San Francisco Bay. The main channel of the slough is over seven miles long and encompasses over 3,00 acres of salt marsh, mudflat, and tidal channels. It is a seasonal estuary (a place where the land's fresh waters meet and mix with the salt water from the sea), which means that the salinity of the wetland changes with the amount of rainfall.

Both the Wetlands of Watsonville and Elkhorn Slough National Estuarine Research Reserve offer guided field trips for students, and will enhance their understanding and appreciation for these unique natural communities.

Activity Procedure

Visiting Elkhorn Slough National Estuarine Research Reserve Visitor Center.

1. To schedule a field trip to Elkhorn Slough, fill out the Field Trip request form and send in at least three weeks in advance. Arrange for transportation and chaperones.
2. When you arrive at Elkhorn Slough, your class will gather at the amphitheater to meet Elkhorn Slough staff and listen to the orientation. Here is some background information they will go over; you may review this with students on your way to Elkhorn Slough.
   - What is an estuary? An estuary is a place where fresh water runs off the land and mixes with the salty seawater. The level of water in the estuary changes with the tide.
   - The Elkhorn Slough is a seasonal estuary. During the rainy season, runoff into the slough dilutes the salt water, making it less salty. In the summer and fall, when there is less rain runoff, the slough is much saltier and acts more like a salt marsh. Occasionally, the water in the upper reaches of the slough evaporates due to hot weather leaving the water concentrated with salt. The Elkhorn Slough is the second largest remaining salt marsh in California; San Francisco Bay Estuary is the largest.
   - Why are estuaries important? Estuaries provide habitats for a variety of plants and animals. Elkhorn Slough is especially important to species that are threatened and endangered. The slough captures all the heavy rains that would otherwise cause flooding, serving an important function in areas subject to floods. It also traps sediments caused by erosion from hills and farms in the area and reduces the amount of sediment that enters the sanctuary.
3. At the amphitheater, Elkhorn Slough staff will discuss their rules about the visitor center and trail etiquette. Students will be directed to the Visitor Center. Allow students at least 15 minutes to explore it on their own. Encourage them to share exciting and interesting things with peers and leaders.
4. After touring the Visitor Center, students will go on a Scavenger Hunt to learn more about the estuary.

Vocabulary

Seasonal Estuary
Slough
Wetland

Journal Prompt

Closing Activity

Review scavenger hunt worksheets. Ask students to share the most interesting fact they learned about wetlands. What was the most beautiful thing they heard or saw? What was the strangest? After seeing wetlands up close and learning about their hidden wonders, do they look at wetlands differently than before?

Activity Extension

If you have time on your field trip day, you may also do this fun bird identification activity. Or, you may identify birds on another day when you can take a walking field trip. You will need binoculars and the bird identification guide from the watershed science kit.

Materials:

- Binoculars
- Bird Identification Guide (from watershed science kit)
- Bird Survey Worksheets
- Clipboard and pencil for each group

Wetlands Exploration

LESSON 4.2

a. Students work in pairs or groups. If you have English language learners, student pairs or groups should consist of one English language learner and one fluent English speaker.
b. Give each group a scavenger hunt sheet, and give them time to walk around the center to solve the riddles and clues to complete the sheet.
c. Go over the scavenger hunt rules with the entire class. Take the short hike down to the lookout point. Here, students will get a good view of the slough, its surroundings, and how it enters the Monterey Bay National Marine Sanctuary.

Copyright.

Visiting Watsonville Wetlands Nature Center

1. Contact the Watsonville Wetlands Nature Center to schedule a field trip by calling them two or three weeks in advance. Arrange for transportation and chaperones.
2. Before you go on the field trip, review with students:
   - Wetlands are a low area between the land and the ocean, where the land is flooded with water.
   - Wetlands carry out many vital functions. They filter sediment and pollution, control flooding, provide homes for migrating birds, and are homes thousands of different animal and plant species, some of them rare or endangered
   - Wetlands are endangered communities—many have been filled in and no longer function as wetlands
3. At the center, staff will give students a brief overview of the nature center and more information about wetlands, then lead the class on a short hike around Struve Slough.
4. They will advise students to make observations or signs of animals, plants and birds, and discuss the importance of restoring habitats.
5. After the tour, allow students time to explore the Nature Center on their own and encourage them to share what they see with peers and leaders.
6. Students work in pairs to complete a Scavenger Hunt. Pair students so that one English language learner and one fluent English speaker work together. Give each group a scavenger hunt sheet, and give them time to walk around the center to solve the riddles and clues to complete the sheet.
7. Check for understanding by reviewing the answers to the Scavenger Hunt as a group.

1. Divide the class into teams with three students in each team. Hand out one pair of binoculars to each team.
2. Demonstrate how to use the binoculars, and how to take turns. At first, tell students to focus on a stationary object, such as a tree. Have each team demonstrate that they can focus the binoculars on an object.
3. Hand out one Bird Survey worksheet and one Bird Identification worksheet to each team.
4. Remind students to hike quietly, so they do not scare away birds. All students will be on the lookout for birds as they walk.
5. Review recording techniques with students:
   - Work cooperatively within your team
   - One student records data, another identifies birds using the ID sheets, and the third student dictates the birds' description as he or she uses the binoculars to get a close look.
- Rotate roles so all get experience with each job
- After you have finished your walk, tally the different types of birds and how many total you saw.
- Review these numbers with students.

Elkhorn Slough Scavenger Hunt

LESSON 4.2

Answer Key

1. **What am I?** I am the place that decides how water will flow and where it will go, but you make the choice of how clean it will be by what you leave on me. *watershed*
   ¿Quien soy? *Yo soy la tierra que decide como corre el agua y a donde va, pero tú decides que limpia será el agua por lo que me tiras encima. cuenca*

2. **What am I?** You would probably never know I was so near, unless you had a long bill to find me in the mud here. *clams, worms, etc.*
   ¿Quien soy? *Debajo del lodo no pensarias buscarme, a menos que tengas un pico largo y grande para encontrarme. almejas, gusanos, y más*

3. Draw 4 things that live in the mudflats.
   Dibuja 4 cosas que viven en el atascadero del lodo.

Anything that lives in the mud...	

4. **What am I?** I fly without noise because it helps me catch prey, but you won't see me much because I'm still during the day. *Barn Owl*
   ¿Quien soy? *Yo vuelo sin ruido para captar mi presa, pero no me verás mucho durante el día porque me tomo la siesta. Búho*

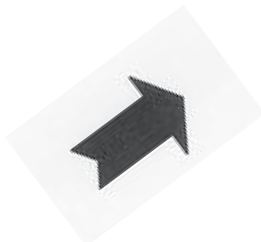
5. **What am I?** I am green when I'm wet, I turn white in the sun, and soak nutrients up just like a sponge. *algae (enteromorpha)*
   ¿Quien soy? *Soy verde cuando estoy mojado pero me blanqueo en el sol, y absorbo nutrientes para crecer mejor. algas (enteromorpha)*

6. **What am I?** I can be so small that you may never see me, but you'll know I exist if the food web stays healthy. *plankton*
   ¿Quien soy? *Yo puedo ser tan pequeño que nunca me veras, pero te darás cuenta que existo si la cadena alimenticia se mantiene sana. plancton*

Answer Key

7. **Find** a Leopard Shark. What does it eat? Use the spinning food web triangles to fill in the blanks in the food chain:
Encuentra un Tiburón Leopardo. ¿ Qué come? Use los triangulos mobiles para completar la cadena alimenticia:

Clam/Almeja



Leopard Shark/Tiburon Leopardo

Plankton/Plancton

8. **Find** 4 animals that depend on the slough.
***Encuentra** 4 animales que dependen de el pantano.*

Name any 4 animals that live in the slough

____

____

9. **Find** 2 plants that belong here (native) and 2 that don't belong here (non-native/invasive).
***Encuentra** 2 plantas que deben vivir aquí (natives) y 2 que no deben vivir aquí (no-nativas/invasivas).*

_____California wild rose (native)
_____Coyote Bush (native)
_____Hemlock (non-native, invasive!!)
_____Wild Raddish (non-native)

10. **What am I?** I hatch from a place that you never would guess; it looks like a branch ball but it's really a wasp nest. *gall (oak gall)*
***¿Quien soy?** Yo salgo de un cascarón que nunca adivinarías. Parezco una rama hinchada pero soy un nido de avispa. avíspero en rama (de roble)*

11. Write down one way that humans can help the plants or animals of the area.
Escribe una manera que las personas pueden ayudar a las plantas y animales de esta área.
Any valid conservation action

Elkhorn Slough Scavenger Hunt

1. **What am I?** I am the place that decides how water will flow and where it will go, but you make the choice of how clean it will be by what you leave on me. ***¿Quien soy?*** *Yo soy la tierra que decide como corre el agua y a donde va, pero tú decides que limpia será el agua por lo que me tiras encima.* ________________________

2. **What am I?** You would probably never know I was so near, unless you had a long bill to find me in the mud here. ***¿Quien soy?*** *Debajo del lodo no pensarias buscarme, a menos que tengas un pico largo y grande para encontrarme.* ________________________

3. Draw 4 things that live in the mudflats.
Dibuja 4 cosas que viven en el atascadero del lodo.

4. **What am I?** I fly without noise because it helps me catch prey, but you won't see me much because I'm still during the day. ***¿Quien soy?*** *Yo vuelo sin ruido para captar mi presa, pero no me verás mucho durante el día porque me tomo la siesta.* ________________________

5. **What am I?** I am green when I'm wet, I turn white in the sun, and soak nutrients up just like a sponge. ***¿Quien soy?*** *Soy verde cuando estoy mojado pero me blanqueo en el sol, y absorbo nutrientes para crecer mejor.* ________________________

6. **What am I?** I can be so small that you may never see me, but you'll know I exist if the food web stays healthy. ***¿Quien soy?*** *Yo puedo ser tan pequeño que nunca me veras, pero te darás cuenta que existo si la cadena alimenticia se mantiene sana.* ________________________

Elkhorn Slough Scavenger Hunt

LESSON 4.2

7. **Find** a Leopard Shark. What does it eat? Use the spinning food web triangles to fill in the blanks in the food chain:
 Encuentra *un Tiburón Leopardo. ¿Qué come? Use los triangulos mobiles para completar la cadena alimenticia:*

____

Leopard Shark/Tiburon Leopardo ____________________

8. **Find** 4 animals that depend on the slough.
 Encuentra *4 animales que dependen de el pantano.*

9. **Find** 2 plants that belong here (native) and 2 that don't belong here (non-native/invasive).
 Encuentra *2 plantas que deben vivir aquí (natives) y 2 que no deben vivir aquí (no-nativas/invasivas).*

10. **What am I?** I hatch from a place that you never would guess; it looks like a branch ball but it's really a wasp nest. ***¿Quien soy?*** *Yo salgo de un cascarón que nunca adivinarías. Parezco una rama hinchada pero soy un nido de avispa.* ________________________

11. Write down one way that humans can help the plants or animals of the area.
 Escribe una manera que las personas pueden ayudar a las plantas y animales de esta área.

Wetlands Scavenger Hunt

Answer Key

1. I determine how water will flow and where it will go, but you make the choice of how clean it will be by the kinds of things you leave on me. What am I? *watershed*
   Yo soy la tierra que decide como corre el agua y a donde va, pero tu decides que limpia será el agua por lo que me tiras encima. cuenca

2. Draw 2 things that live in the wetlands.
   Dibuja 2 cosas que viven en el pantano.

Anything living in the wetland...	

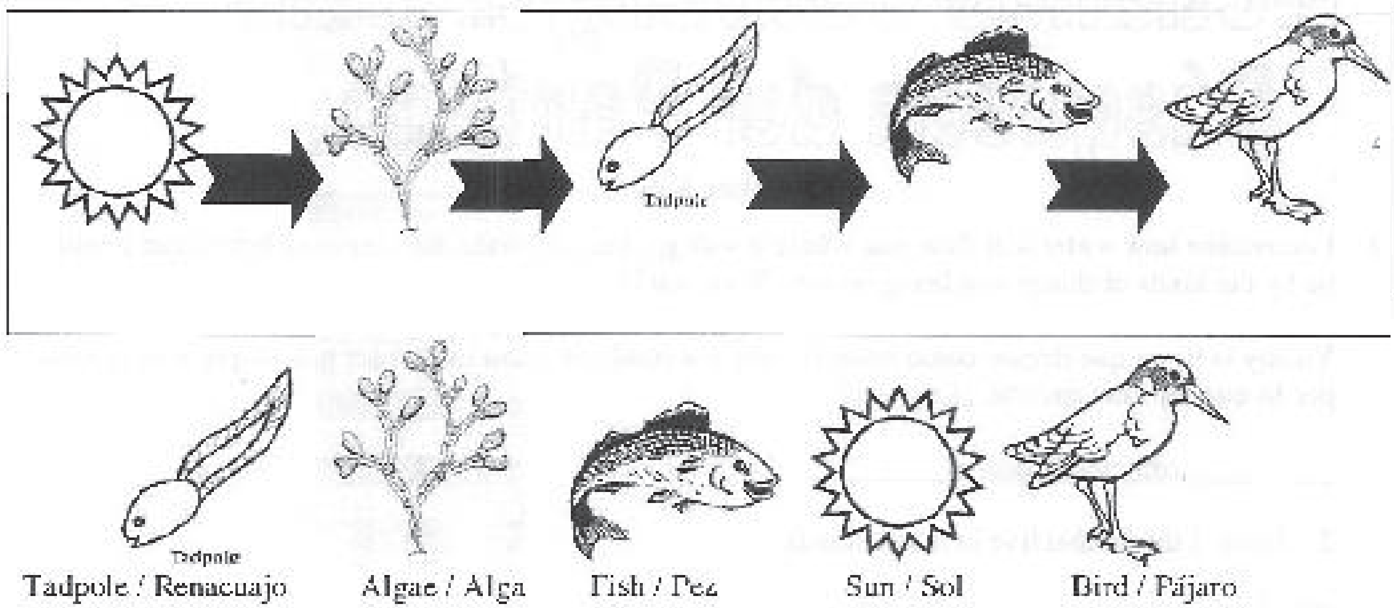
3. Listen carefully. What do you hear? Put an X next to each thing you hear.
   Escucha cuidadosamente. ¿Qué es lo que oyes? Pon una X al lado de cada cosa que oigas.

   The noise of an insect / *El ruido de un insecto* ______
   Birds singing / *El canto de pájaros* ______
   Something swimming in the water / *Algo nadando en el agua* _____

4. Where does the water from this wetland go?
   ¿A dónde va el agua de este pantano?
   absorbs into the groundwater and spills into some creeks

Answer Key

5. Complete the food chain by putting each organism in its proper place.
   Completa la cadena alimenticia poniendo cada organismo en el lugar correcto.



6. I support a huge number of insects, fish, birds and other animals. My still waters make good breeding and nursery areas. One of my jobs is to filter out pollutants before they spread throughout the environment. Who am I? *wetland*
   Yo soporto muchos insectos, peces, pájaros y otros animales. Mis aguas quietas sirven como áreas de criar y viveros. Unos de mis trabajos es filtrar contaminantes antes de que llegue a otros habitats. ¿Quien soy? pantano (humedal)

7. What is one way that we, as humans, can help the plants or animals of this area?
   ¿Qué es una cosa que nosotros podemos hacer, como ser humanos, para ayudar a las plantas y los animales de este área? any appropriate conservation answer

Wetlands Scavenger Hunt

1. I determine how water will flow and where it will go, but you make the choice of how clean it will be by the kinds of things you leave on me. What am I? *Yo soy la tierra que decide como corre el agua y a donde va, pero tu decides que limpia será el agua por lo que me tiras encima.* ________________________

2. Draw 2 things that live in the wetlands.
Dibuja 4 cosas que viven en el pantano.

Anything living in the wetland...	

3. Listen carefully. What do you hear? Put an X next to each thing you hear.
Escucha cuidadosamente. ¿Qué es lo que oyes? Pon una X al lado de cada cosa que oigas.

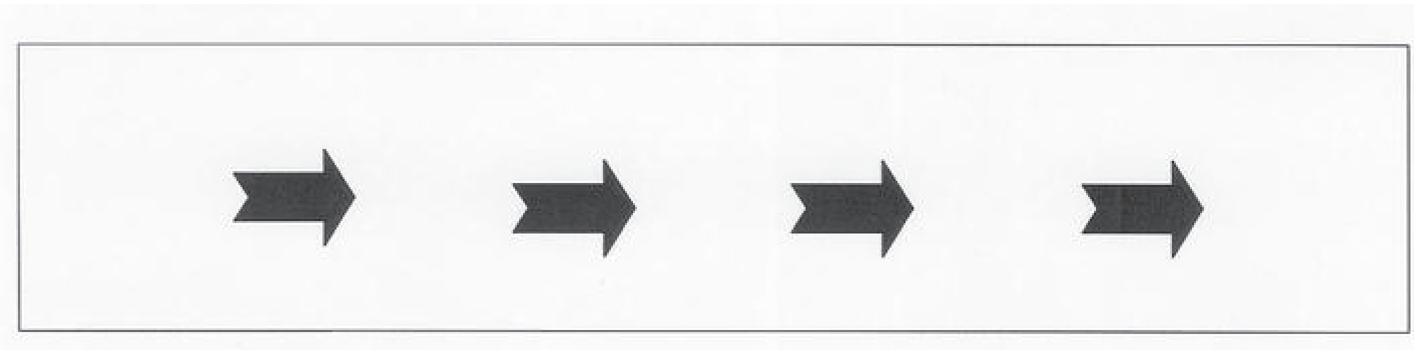
The noise of an insect / *El ruido de un insecto* ______
Birds singing / *El canto de pájaros* ______
Something swimming in the water / *Algo nadando en el agua* _____

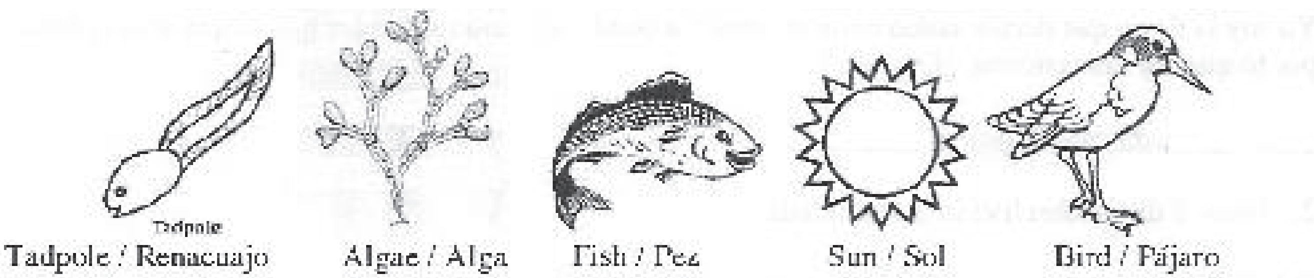
4. Where does the water from this wetland go?
¿A dónde va el agua de este pantano?
____

Wetland Scavenger Hunt

LESSON 4.2

5. Complete the food chain by putting each organism in its proper place.
Completa la cadena alimenticia poniendo cada organismo en el lugar correcto.





6. I support a huge number of insects, fish, birds and other animals. My still waters make good breeding and nursery areas. One of my jobs is to filter out pollutants before they spread throughout the environment. Who am I? *Yo soporto muchos insectos, peces, pájaros y otros animales. Mis aguas quietas sirven como áreas de criar y viveros. Unos de mis trabajos es filtrar contaminantes antes de que llegue a otros habitats. ¿Quien soy?*
____

7. What is one way that we, as humans, can help the plants or animals of this area?
¿Qué es una cosa que nosotros podemos hacer, como ser humanos, para ayudar a las plantas y los animales de este área? ____

Bird Survey
Encuesta de Pájaros

Bird Name or Description *Nombre del Pájaro o Descripión*	Behavior *Comportamiento*	Location *Locación*	Count *Cuenta*

Rivers Meet the Salty Sea

LESSON 4.3

Summary

When fresh water meets salt water, as happens in an estuary, they do not mix equally due to the differences in density between the two waters. Students observe this first-hand by conducting wet lab experiments in the classroom that introduce fascinating topics involving density and layering. Students play an Estuary Life Clue Game and discover how layering of fresh and salty water creates a rich and diverse ecosystem for plants and animals.

Learning Objectives

Students will be able to:

- Know that fresh water and salt water have different densities
- Describe what happens when fresh water and salt water meet in an estuary such as Elkhorn Slough.
- Explain why Elkhorn Slough is a seasonal estuary
- Name three organisms that live in estuaries, and one adaptation of each organism

Background

A slough is a shallow, flat wetland composed primarily of stagnant, or slow moving water. A slough may be removed from a source of water, like a low area in a meadow. Some sloughs are formed by rivers or streams not connected to the ocean. Unlike sloughs, estuaries are connected to the ocean; freshwater flows into the wetland on one end and saltwater from the sea on the other. The water level changes with the tides. When the tide is in, estuaries and salt marshes are flooded with seawater. When the tide is out, much of the mudflats are exposed.

Copyright.

Elkhorn Slough is located between a river and an estuary. When it rains in the winter, freshwater runoff from land drains into the slough and meets saltwater entering from the sea. During the rainy season, runoff into the slough dilutes the salt water, making it less salty. In the summer and fall, when there is less rain, and several months of sunshine have evaporated much of the water, the slough's salinity increases. This saltier slough acts more like a salt marsh. Occasionally, the water in the upper reaches of the slough evaporates entirely, leaving dry salt beds. The seasonal variations in salinity and concentrations of fresh and salt water make Elkhorn Slough a seasonal estuary.

Duration

Density Experiment:
60 minutes
Estuary Life Clue Game:
20 minutes

Teacher Prep

1. Read activity background.
2. Make salt water: Make this early in the day, or the day before the experiment. Add 35 grams of salt to one liter of warm water, or 2 tablespoons of sea salt to 1-quart warm water. If made the day before, be sure to shake and mix the saltwater solution well before using. Add red food coloring to the salt water.
3. Gather materials for density experiment. Try the experiment on your own before class, to see how it works.
4. Photocopy and cut the thirty Estuary Life Clue Strips.
5. From the species cards, select the cards for the egret, crab, clam, fat innkeeper worm, and pickleweed.

Rivers Meet the Salty Sea

LESSON 4.3

Materials

- Rivers Meet Salty Sea worksheet
- Salt
- Tap water
- Pitcher or one gallon plastic milk container for pouring water

For each group of four students, plus one used as a demonstration:

- Clear 9"x 11" baking dish or see-through container
- Paper cup filled with small pebbles
- Pencil
- Red food coloring
- One- to two-inch thick book
- Estuary Life Clue Strips Species cards: egret, crab, clam, fat innkeeper worm, and pickleweed (from science kit)

Vocabulary

Adaptation
Density
Elkhorn Slough
Estuary
Salinity
Salt Marsh
Slough
Tides

Density is a measure of how much a given volume of something weighs. If you were to pour equal amounts of freshwater and saltwater and weigh them both, the freshwater would weigh less than the saltwater. If you put the two waters together, the salt water would sink below the layer of freshwater.

When freshwater enters Elkhorn Slough as runoff, it initially floats on top of the saltwater from the sea. During the rainy season, the waters of Elkhorn Slough are layered with a freshwater layer above and a saltwater layer below. As wind and water movement mix the layers, a third "mixed" layer is added. These varied water layers support a variety of different types of organisms - some able to survive in saltwater, some able to survive in freshwater, and others able to survive in a variable mixture of the two. The variable salinity of Elkhorn Slough provides more habitats than freshwater or saltwater alone. Plants and animals that live in estuaries have adaptations that allow them to live in water that has changing salinities.

Activity Procedure

Rivers Meet the Salty Sea

1. Review the term runoff with your students and ask them to tell you what it is (rainwater that does not soak into the ground, but runs off into creeks, estuaries, and/or storm drains). Along the central coast, all our coastal streams and rivers drain into the ocean. What happens when rivers and the ocean meet? Have students share their thoughts about what kind of water is created when fresh and salt water meet, and how it affects the kinds of plants and animals that live there. Most organisms live in either salt water or freshwater. Plants and animals that live in estuaries have adaptations that allow them to live in water that has changing salinities.
2. Using the directions on the Rivers Meet the Salty Sea worksheet, demonstrate the experiment to the students.

Copyright.

3. Hand out the worksheets and have students follow directions to conduct their own experiments.
4. As a follow-up, discuss what the students learned about salinity and how it affects the organisms living in the slough and estuary. Discuss what kinds of adaptations an organism would have to have in order to live in a habitat like that.

Can’t find missing file - Insert Figure 4.3 Experiment Set-up

Estuary Life Clue Game

Plants and animals that live in estuaries and salt marshes have special adaptations to living in a habitat with changing salinities and water levels. Some burrow beneath the mud and stick out a siphon, while others have special adaptations that allow them to walk easily on the mud. Invertebrate, bird, or plant—students will now play a game where they will match species with their lifestyle clues.

1. Make a copy of the attached Estuary Life Clue Strips and cut them into strips before class.
2. Write the names of the animals and plants on the board and tape the species cards under their name to help students match the clue with the species.
3. Shuffle Estuary Life Clue Strips and let students pick out of a hat one or two strips (depending on size of class) each. Teacher Tip: Hand out all clues (30 total).
4. Students stand around the room so they can mingle freely.
5. Tell students the goal of the game is to discover the identity of each of the five animals or plants by gathering all six clues that describe each of them.
6. Students begin when you give the signal. Tell students each organism has six clues.
7. Students read their clue strips, and call out the names of animals or plants they guess their clue strips match.
8. As students hear the various names called, they check their clue to see if it could possibly match what they are hearing. They join the person or group with which their clue belongs.
9. Check each group’s strips only when they say they have collected all the clues; use the Teacher Key to see if they have assembled the right clues.
10. Once every clue has been identified and gathered, have groups read out loud who they are, and two or three of their most interesting clues.

Journal Prompt Closing Activity

Students have experimented today with water density. From their experience, students write in their journal their ideas about density. What is density? How does it make a difference in whether things float or sink? Draw a picture and explain the concept of density as though you had to teach it to a second grader.

Activity Extensions

Do “sink or swim” experiments with freshwater and saltwater. Place objects of different weights in fresh water and salt water and see if they float at the same level. Does salt water float things that sink in freshwater? Using an old film canister, put pennies in it until it sinks. Is the amount of pennies it takes to sink the same in salt water as it is in fresh water? Ask students to come up with hypotheses to determine if objects float better in salt water or fresh water.

Rivers Meet the Salty Sea

LESSON 4.3

Name ___________________________________

Materials
- Pan
- Paper Cup
- Pencil
- Rocks or marbles (3-5 per group)
- Red-colored Salt Water
- Pitcher or container for pouring water
- One- to two-inch thick book

Hypothesis:
What do you think will happen when you add salt water to fresh water? Write your hypothesis here:

Procedure:
1. Pour room temperature tap water into the pan until it is about 1 inch from the top. Place one end of the pan on a one inch book so the pan is at an angle. The deep end should be 1/2 inch from the top of the pan.

2. Use the tip of a pencil to poke several small holes in the bottom of the paper cup. Use small rocks or marbles to weigh down the cup.

3. Place the cup in the deep water end of the pan. Wait about three minutes for the water to settle.

4. Slowly pour the colored salt water into the cup with pebbles (introduce the salt water very gradually, just as the rising tide gradually enters an estuary). Watch closely through the sides of the pan. Do not move the pan or touch the water in any way. Pour the water very slowly into the cup.

5. Describe what you observed here:

Cuando Los Ríos se Juntan con el Mar Salado

LESSON 4.3

Nombre ___________________________________

Materiales
• Bandeja
• Vaso
• Lápiz
• Piedras o canicas (3-5 por grupo)
• Agua Salada de Color Rojo
• Pichel o contenedor para el agua
• Libro grueso de 1-2 pulgadas

Hipótesis:
¿Qué crees que va a pasar cuando le eches agua salada a la bandeja con agua dulce? Escribe tu hipótesis aquí:

Procedimiento:
1. Llena la bandeja con agua de la llave, pero deja como una pulgada antes de que se llene hasta arriba. Pon la bandeja arriba de el libro formando un ·ngulo. La parte más profunda debe de estar como media pulgada de la parte de arriba de la bandeja.

2. Usa la punta del lápiz para hacer varios hoyitos en la parte de abajo del vaso de papel. Pon las piedras o canicas dentro del vaso para sostenerlo dentro del agua.

3. Pon el vaso con piedras en la parte profunda de la bandeja. Espera unos minutos para que el agua se calme.

4. Muy despacio echa el agua salada roja dentro del vaso con piedras (introduce el agua salada gradualmente y suavemente, así como la marea del mar entra al estuario). Mira cuidadosamente en los lados de la bandeja para ver que pasa. No muevas la bandeja o toques el agua. Echa el agua muy despacito.

5.Describe lo que observas aquí:

Estuary Life Clue Game

Juego de pistas: vida en el estuario

Clue strips for students
I have adapted to live in very salty conditions. *Me he adaptado a vivir en condiciones muy saladas.*
I am not very tall, I can be found low to the ground. *No soy muy alto, me puedes encontrar cerca del suelo.*
I change colors. During the spring and summer I am green, but in fall I turn red-orange. *Cambio de colores.* *En la primavera y el verano soy verde, pero en el otoño cambio a ser rojo-anaranjado.*
If someone ate me, I would taste very salty. I am saltier than the water in which I grow. *Sí alguien me comiera, mi sabor sería muy salado. Soy más salado que el agua en la que crezco.*
I make my own food using the sun's energy. *Yo haga mi propia comida usando la energía del sol.*
I have no leaves. *No tengo hojas.*
I live in an area where fresh and salt water come together. *Vivo en el lugar donde el agua salada y el agua dulce se juntan.*
I am fat and pink, but that does not mean I am a pig. *Soy gordo y rosado, pero no soy un cerdo.*
I live in the mud. I make a U-shaped tunnel that I share with other animals like gobies and crabs. *Vivo en el lodo.* *Hago un túnel en forma de una U, y lo comparto con otros animalitos como el cangrejo y unos pescaditos.*
Even though I share my home with other animals, you will hardly ever see me. I am very fast because I move my body in wavelike motions to escape from predators. *Me arrastro por el suelo con mucha velocidad para escapar de mis predadores.*
When I make my tunnels, I create a net of mucus that helps me trap food. *Cuando hago mis túneles, les pongo una red que hago con mis mocos para atrapar mi comida.*
I pump water through my home. This helps me trap small bits of food to eat. *Para atrapar pequeños pedazos de comida, tengo que bombear agua por mi casa.*
I live below the surface of a place that has a lot of salt. *Vivo debajo del suelo en un lugar que tiene mucha sal.*

Estuary Life Clue Game

Juego de pistas: vida en el estuario

LESSON 4.3

Clue strips for students
I use my foot for digging straight down into the mud. *Uso mis patas para escarbar hoyos en el lodo.*
I have two tubes inside me, one called a siphon. I use one of my tubes to suck up food, and I use the other to get rid of waste. *Tengo dos tubos dentro de mi, uno se llama sifón. Uso mis tubos para chupar mi comida y para echar fuera los desperdicios.*
I like to hide in the mud because I do not want to be eaten. When I am scared, I shoot out water from my siphon. *Me gusta esconderme en el lodo porque no quiero que me coman. Cuando tengo miedo aviento agua por mi sifón.*
I have a hard shell as protection. Although my shell is hard there are still animals that like to eat me. Some of them are otters and egrets. *Tengo una concha protectora. Aunque mi concha es dura, hay unos animales que les gusta comerme, como las garzas y nutrias, marinas.*
You find my shell on Sanctuary beaches. You must remember not to collect it and take it home because other animals might use it as shelter. *Puedes encontrar mi concha por el Santuario, aunque tienes que recordar que no debes de llevártela porque otros animales la usan para protegerse.*
I like visiting areas where fresh and saltwater meet. *Me gusta visitar áreas donde el agua dulce y el agua salada se juntan.*
I have long black legs and toes that help me walk in the mud easily. *Tengo piernas y dedos negros y largos que me ayudan a caminar por el lodo muy fácilmente.*
I love to catch and eat fish, worms, crabs, and other invertebrates. *Me gusta atrapar y comer pescados, gusanos, cangrejos y otros invertebrados.*
I can grow pretty tall for my species. I can get up to 4 1/2 feet tall. *De las de mi especie, yo puedo crecer muy alto. Puedo llegar a medir más que 4 pies y medio de altura.*
Don't be afraid if you hear me. I have a rough, deep voice. *No te espantes sí escuchas mi voz, ya que es muy ronca y profunda.*
I have the ability to fly. Sometimes I will leave behind my long white feathers. *Puedo volar, a veces dejo detrás mis plumas blancas.*

Estuary Life Clue Game

Juego de pistas: vida en el estuario

Clue strips for students
I can be found walking around wet salty places. *Me puedes encontrar caminando por lugares salados y mojados.*
I search for shelter if I see someone approaching. I try pressing myself into cracks to hide from people or other animals. *Cuando veo a alguien acercase, busco en donde esconderme. A veces me escondo en grietas o aberturas que encuentro.*
Seagulls like to eat me, but I spread my legs against a rock and hold on tight so it is harder for them to pull me off. *Las gaviotas les gustan comerme, pero me presiono contra las piedras para agarrarme fuerte para que no me puedan arrancar.*
I have gills. I can feed in the open air and return to the water if my gills get too dry. *Tengo agallas. Puedo comer al aire libre y regreso al agua cuando mis agallas se me secan.*
My favorite food is algae. I scrape algae off rocks above and below the surface of the water by using my spoon-shaped claw. Mi comida favorita son las algas. *Me como las algas que están pagadas en las piedras arriba y debajo del agua.*
When I am hungry, I am not a picky eater. I am fast enough to catch flies by their wings and I will also eat old bait and tourist's lunch scraps. *No soy delicado cuando tengo hambre. Soy tan rapido para agarrar moscas por sus alas y también como los restos de carnada que dejan los pescadores y las sobras de sus lonches.*

Rivers Meet the Salty Sea Activity was adapted from Waves, Wetlands, and Watersheds, Coastal Commission Science Activity Guide Edge of the Wedge
Estuary Life Clue Game was adapted from Sharing Nature with Children II Animal Clue Game

Answer Key

Pickleweed

- I have adapted to live in very salty conditions.
- I am not very tall. I can be found low to the ground.
- I change colors. During the spring and summer I am green, but in fall I turn red-orange.
- If someone ate me I would taste very salty. I am saltier than the water in which I grow.
- I make my own food using the sun's energy.
- I have no leaves.

Fat innkeeper worm

- I live in an area where fresh and salt water come together.
- I am fat and pink but that does not mean I am a pig.
- I live in the mud. I make a U-shaped tunnel that I share with other animals like gobies and crabs.
- Even though I share my home with other animals, I am hard to find. I am very fast because I move my body in wavelike motions so that I can escape from predators.
- When I make my tunnels, I create a net of mucus that helps me trap food.
- I pump water through my home. This helps me trap small bits of food for me to eat.

Clam

- I live below the surface of a place that has a lot of salt.
- I use my foot for digging straight down into the mud.
- I have two tubes inside me, one called a siphon. I use one of my tubes to suck up food and I use the other to get rid of waste.
- I like to hide in the mud because I do not want to be eaten. When I get scared I shoot out water.
- I have a hard shell as protection. Although my shell is hard, there are still animals that like to eat me. Some of them are otters and egrets.
- You can find my shell along sanctuary beaches. You must remember not to collect my shell and take it home because other animals might use it as shelter.

Egret

- I like visiting areas where fresh and salt water meet.
- I have long black legs and toes that help me walk in the mud easily.
- I love to catch and eat fish, worms, crabs, and other invertebrates.
- I can grow pretty tall. I can get up to 4 1/2 feet tall.
- Do not be afraid if you hear me. I have a hoarse, deep voice.
- I can fly. Sometimes I will leave behind my long white feathers.

Crab

- I can be found walking around wet salty places.
- I search for shelter if I see someone approaching me. I try pressing myself into cracks to hide from people or other animals.
- Seagulls like to eat me, but I spread my legs against a rock and hold on tight so itís harder for them to pull me out.
- I have gills, can feed in the open air and return to the water if my gills get too dry.
- My favorite food is algae. I scrape the algae off rocks above and below the surface of the water by using my spoon-shaped claw.
- When I am hungry I am not a picky eater. I am fast enough to catch flies by their wings and I will also eat old bait and tourist's lunch scraps.

Invasive Crab Monitoring

LESSON 4.4

Summary

Students take a field trip to Elkhorn Slough and use scientific methods to collect data on the European green crab, an invasive species.

Learning Objectives

Students will be able to:

- Identify native and non-native crab species in Elkhorn Slough
- Know how to measure the width of each crab's shell, determine the crab species, and the sex of the crab
- Conduct procedures for crab population monitoring
- Describe two ways that invasive non-native species can affect native species

Background

The term "invasive species" refers to species that have been moved beyond their original range by human activities. There are a variety of other terms used to describe invasive species including introduced species, exotics, aliens, nuisance species, and non-indigenous species. No matter what they are called, invasive species can change the relationships and interactions among living organisms and their environment.

Species get "introduced" to a new area through a variety of ways, including the aquarium trade, ballast water on ships from foreign countries, aquaculture, live bait, hull fouling, restaurant trade, and aquatic or airborne dispersal of larvae or spores. Even research and education facilities have introduced species to a new environment when organisms escaped or were accidentally released.

Successful invaders can cause complex changes within their new ecosystem. These include competition with native species for food and space, changes in predator-prey interactions, the addition of new diseases or parasites, and ecological and economic damage. With its international harbor and extensive shipping commerce, San Francisco Bay now has over 230 introduced species, all competing for food and space with the native species of marine organisms. There are approximately 40 invasive species in Elkhorn Slough, and another small handful of species recently reported in near shore coastal waters.

Copyright.

Duration

90 minutes plus travel time from school

Teacher Prep

1. Arrange for field trip to Elkhorn Slough for crab monitoring.
2. Arrange for transportation and chaperones.
3. Read activity background.
4. Tell students the day before the field trip to wear clothing that can get dirty, and bring sensible shoes with closed toes. Elkhorn Slough can become windy—layers are always recommended.

Materials

- Crab Identification Sheets (provided in kit)
- Crab Monitoring Data worksheet (provided at Elkhorn Slough)

Invasive Crab Monitoring

LESSON 4.4

Vocabulary

Ecosystem
Invasive
Monitoring
Native species
Non-native species

Journal Prompt

Closing Activity

Back in the classroom, go over these questions with students and have them put their thoughts down in their journals: Why do you think these crabs are invading the Elkhorn Slough? What might be found here that attracts and keeps them in this area? How might this affect the native crabs? How might these crabs affect the animals that eat native crabs? What is the biggest problem with the invasive crab population increasing in Elkhorn Slough?

The European green crab has recently been detected in Elkhorn Slough, where there is concern that this invasive crab is preying on smaller native crab species. Voracious predators, green crabs feed on numerous invertebrates including native mussels, clams, oysters, crabs and polychaete (segmented) worms. Green crabs change the biological diversity of an area and the abundance of native invertebrates.

Monitoring is the practice of taking the same measurements in the same place over time, often a series of years or decades. Scientists, teachers, and students at Elkhorn Slough are monitoring crab populations to determine where green crabs are invading, how quickly their populations are increasing, and how they are impacting native crab populations.

Activity Procedure

1. Contact the MERITO staff to schedule an invasive crab monitoring field trip at the Elkhorn Slough National Estuarine Research Reserve.
2. Before the field trip, make an overhead of the Crab Identification Sheet. Introduce the class to the body parts and vocabulary on the worksheet, and answer questions they may have. Explain these key facts with them:
   - Green crab numbers have increased, and now there is concern that the invasive green crab is eating smaller native species of crabs.
   - Scientists have developed a monitoring study to record the increase in invasive crabs and observe any declines in native species.
   - We are fortunate to be able to participate in Elkhorn Slough's monitoring efforts.
   - When the class arrives, they will meet MERITO staff at the visitor's center and walk to the crab monitoring site.
   - Staff will instruct students how to collect crabs, measure shell width, determine the species and the sex of the crab. Students will use crab identification sheets provided by the staff for reference, and will record information on Crab Monitoring data sheets.
   - When the monitoring activity is finished, staff will discuss the importance of today's findings with the students.

Activity Extensions

Going to Elkhorn Slough is always a fun experience, but with this activity, students gain a deeper understanding of one of the resource management issues of a natural reserve. You cannot just close the door and tell invasive species they are not welcome! Have a class wide discussion where students can brainstorm ways that the European green crab population might be controlled in Elkhorn Slough. Who would be responsible? How would they do it? What might be some impacts to other species in the slough? What have other organizations done to try to keep the spread of invasive non-native species in check? Your class can participate in community activities that seek to control the spread of non-native species. Contact Sanctuary or Elkhorn Slough staff for recommendations of restoration activities in which your students may participate.

Parts of a Crab

Antennae
Claw
Eye
Teeth
Carapace
Legs
Abdomen

How to measure crabs
Measure crabs, in millimeters, along the widest part of the crab's carapace.

Sex
Abdomen of male crab is triangle shaped
Abdomen of female crab is oval shaped

Name: Striped Shore Crab (native)
Carapace: Square shaped
Teeth: 2 on the carapace after the eyes
Color: Blackish green with red or purple stripes or markings
Other Facts: Eyes are at the corners

Name: Yellow Shore Crab (native)
Carapace: Square shaped
Teeth: 3 teeth on carapace
Color: Brown or grayish green but can sometimes be white
Other Facts: Has hairy legs, no stripes

Name: Pacific Rock Crab (native)
Carapace: Wide, oval and shaped like a fan
Teeth: 5 teeth on the carapace between the eyes
Color: Reddish brown
Other Facts: Carapace is widest at the 8th tooth and the claws are big with black tips

Name: European Green Crab (non-native)
Carapace: Wide not very long
Teeth: 5 teeth on the carapace after the eyes
Color: Multicolored, greenish or orange
Other Facts: 4th pair of each leg is flattened

Name: Pacific Staghorn Sculpin (native)
Body: Stretched and without scales
Head: Long, flat underside and large mouth
Fins: Yellow pectoral fins and spiny dorsal fin with black spot

Partes de un cangrejo

Tenazas
Antena
Diente
Ojo
Caparazón
Piernas
Abdomen

Como medir cangrejos
Mida cangrejo, en milímetros, a lo largo de la parte mas ancha del caparazón.

Sexo
Abdomen de cangrejo masculino en forma de triangulo
Abdomen de cangrejo femenino en forma de oval

Nombre: Cangrejo Costero Alineado (nativo)
Caparazón: Cuadrado
Dientes: 2 dientes en su caparazón junto a cada ojo
Color: Negro-verde con rayas rojas o moradas
Otros Datos: Los ojos están en las esquinas

Nombre: Cangrejo Costero Amarillo (nativo)
Caparazón: Cuadrado
Dientes: 3 dientes en el caparazón
Color: Café o gris-verde, pero a veces puede ser blanco
Otros Datos: Tiene piernas peludas, sin rayas

Nombre: Cangrejo Pacifico de Roca (nativo)
Caparazón: Ancho y ovalado en forma de abanico
Dientes: 5 dientes entre los ojos
Color: Rojo-café
Otros Datos: Es mas ancho en el 8vo diente y sus tenazas son largas con puntas negras

Nombre: Cangrejo Verde de Europa (no-nativo)
Caparazón: Ancho y no muy largo
Dientes: 5 dientes grandes al lado de cada ojo
Color: Coloreado, con manchas verdes o anaranjadas
Otros Datos: El 4to par de piernas esta aplanada

Nombre: Pacific Staghorn Sculpin (nativo)
Cuerpo: Alongado sin escamas
Cabeza: Larga y aplanada con boca grande
Aletas: Pectorales amarillosas y dorsal espinosa con manchas negras

Mudflat Exploration

LESSON 4.5

Summary

With the intrepid MERITO staff as their guides, students visit the mudflats at the north end of Moss Landing Harbor to find different species that live on and in the mud, learn about mudflat creatures, and the adaptations that help them live there.

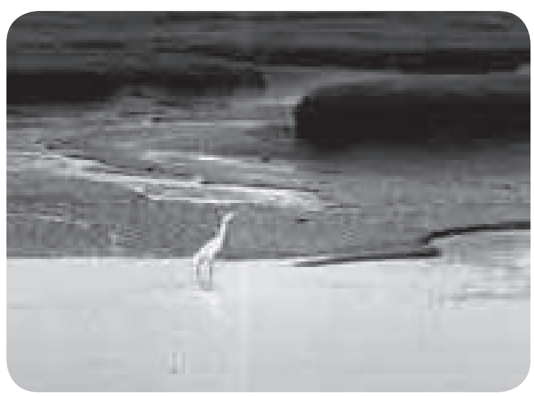
Learning Objectives

Students will be able to:

• Define what makes a mudflat a unique community
• Describe what to look for as evidence of mudflat life
• Identify and describe two organisms that live in mudflats
• Describe two adaptations organisms have to living in mudflats

Background

Mudflats are found in areas where water movement is shallow and slow. This "slow flow" of the water allows the smallest particles carried in the water, like clays and silts, to settle out. As the particles settle they form a flat, muddy bottom called a mudflat. Higher tides cover mudflats with a layer of water, bringing food and oxygen to organisms living in the mud. When the tides go out, mudflats are exposed to the air, unveiling hidden secrets about life in the mud.



Copyright.

Mudflat plants and animals have adaptations, or structures and behaviors that help them survive in their environment. Some animals dig a hole or tunnel as a living space into the soft muddy bottom. Burrowing helps animals hide from predators while the tide is out. When the tide comes in, their holes are filled with food and oxygen-rich water. Many mudflat organisms are filter feeders they filter nutrients from the water as it flows over them.

A low mound of mud may mark the U-shaped burrow of the fat innkeeper worm. This worm pumps water from one end of the burrow to the other using a wave-like motion of its body. The worm casts a net of mucus from its mouth to one side of the U-shaped tunnel and uses the net to filter food from the water, then eats the mucus net. Called a fat innkeeper, is about the width of a hot dog and may "host" (as an innkeeper does) other animals like crabs, fish, and worms in its burrow.

Duration

60 minutes, plus drive time

Teacher Prep

1. Arrange a field trip date with MERITO staff
2. Arrange transportation and chaperones
3. Read activity background
4. Gather materials

Materials

• Mudflat ID sheet (provided in kit)
• Shovels (provided by MERITO staff)
• Dishpans (provided by MERITO staff)
• Magnifying boxes (provided in kit)

Mudflat Exploration

Vocabulary

Adaptation
Food chain
Mudflat

Journal Prompt Closing Activity

To help them connect the pieces of the mudflat food chain, ask students this question: We all know that energy travels through an ecosystem in food chains, where one organism eats another. What do you think is the base of the food chain in mudflats?

The answer is Plankton and detritus from decaying plants and animals. Many mudflat inhabitants are detritivores—they eat mainly detritus. They filter plankton and detritus from decaying algae and plants and organic matter from decaying animals.

Imagine you live beneath the mud. What adaptations do you have that help you survive in the mudflats? Who is your main predator? How do you eat? What happens if pollution enters your water and mud? How does it affect you? How does it affect your main predator? You may draw yourself as part of the entry.

The burrowing tubeworm makes its own tube by mixing mucus with sand. The tube sticks up about an inch above the mudflat. This worm waits for the tide to arrive, extends a circle of tentacles into the water, collects organic matter from the surface of the mud, and eats the organic matter. When the tide goes out, the sandy tube provides evidence of the worm living below.

Other burrowing worms ingest (eat) the mud and eat the organic matter trapped within the mud particles. Lugworms create L-shaped burrows and ingest mud. As the mud passes through the worm's body, organic matter is absorbed. The worm then defecates (poops) the remaining mud into a mound on the surface. These fecal mounds, created by lugworms and many other types of mud-dwelling organisms, provide signs of life below.

Clams have also adapted to mudflats by burrowing into the mud. Clams have a soft body protected by two shells and siphons used to direct water into and out of the clam. The straw-like siphons enable clams to reach the water above to feed, while the body of the clam stays protected under the mud. Like the head of a land turtle, a clam's siphons can be extended or retracted. Most clams also have a foot used for digging or burrowing.

In addition to worms and clams, a number of other organisms make a living on mudflats. Crabs and snails cruise the mudflats in search of a meal. These mud crabs feed upon detritus (particles from dead plants and animals). The moon snail glides along the mudflat using a mucus-lined foot. Moon snails reach the size of a fist and use a big, muscular foot in search of clams. When a moon snail finds a clam, it wraps its foot tightly around the clam, then drills a hole into the clam's shell using a file-like tongue called a radula. The moon snail uses a special liquid to dissolve the body of the clam and then gulps it up!

When the tide goes out, birds arrive to search for a tasty meal leaving footprints as evidence of their presence. Some birds are able to reach favored prey items hiding beneath the mud using specially designed beaks. They may also dine on other predators, like snails and crabs, cruising the surface of the mudflat.

Mudflat Exploration

Activity Procedure

1. Arrange with MERITO staff a day for the field trip. Organize transportation and chaperones.
2. Before you leave the classroom review Trail Manners and Ocean Safety (in Appendix) and also explain how to handle animals and behave in mudflats.
3. When your class arrives at the field trip site, divide the class into four groups, and hand out the ID sheets, magnifying boxes, and a tub to each group.
4. Hold up the Mudflat ID sheet, and go over the species listed so students can have an idea of what they might find. Explain to students that it is important that they carefully observe the surface of the mud before they start digging. There is much evidence on the surface of what lives beneath.
5. With the help of MERITO staff, each group will dig a 1- to 2-foot deep hole with the shovels.
6. Tell students to look for the many different species that live in the mudflats. Carefully collect what you find, and place it in your tubs. Select two animals to show the group.
7. Use the ID sheets and be prepared to answer these questions:
   - What is it?
   - Where in the mud did you find it?
   - What does it eat?
   - What eats it?
   - What is a cool adaptation it has to living in the mud?
8. Give students 25-30 minutes to explore. Gather the groups back and have them present one or two of their favorite species, answering the questions above.
9. Carefully replace the organisms and mud in the holes before leaving. Discuss the importance of exploring a natural place to learn about it, but not have a negative impact on it.

Activity Extensions

Conduct a bird survey as in the Wetlands Exploration extension. Or visit the visitor center at Elkhorn Slough National Estuarine Research Reserve with your class. They have excellent models of life beneath the mud, and wetland birds. You will have a chance to see a 3-D topographic map where the mud in the mudflats originates.

Birds and Their Bills

LESSON 4.6

Summary

In this activity, students explore the different types of adaptations found in birds, and how bird bills are uniquely shaped to accommodate the foods they eat. They "compete' for food in a timed activity. As an extension, students take a Bird Survey Nature Walk where they use binoculars and bird identification sheets to identify and count birds at their school site or playground.

Learning Objectives

Students will be able to:

- Name two special features of birds
- Describe how bird adaptations ensure survival
- Name two adaptations birds have for flight
- Collect experimental data, record it, and create a bar graph to display results

Background

There are thousands of different kinds of birds—Elkhorn Slough alone supports 346 species of resident and migratory birds! The array of adaptations seen in birds presents an opportunity to understand how adaptations ensure the survival of a species and how bird bills, feet, and body types can tell us a great deal about habitat and food preferences.

Shorebirds and seabirds are a diverse group of animals, but can typically be categorized into very general groups based on how each group feeds. Because the birds in each group feed in similar ways or live in similar habitats, the birds in each group share some common adaptations for survival.

Copyright.

Duration

Duration: 60-90 minutes

Teacher Prep

1. Read activity background
2. Gather materials. Teacher tip: The materials list is extensive. Allow time to gather enough for all students to participate. Students can help by bringing items on the list from home. Begin gathering materials a few weeks before you conduct the activity.
3. The day of the activity, set up the stations before students arrive. The number of stations you set up is dependent upon the number of groups you have (four students per group). At each station, place a complete set of the bill utensils (one utensil for each student), a paper cup for each student, a large piece of butcher paper, a pencil, and four different colors of pen or crayon.

Birds and Their Bills

LESSON 4.6

Materials

- Field journals
- Graph paper
- Colored pens or crayons
- Bird poster or bird ID sheets (from watershed science kit)

For each group of four students, set up stations:

- Paper cups, one per student
- One pair of chopsticks
- One spring-type clothespin
- One pair of tweezers
- One spoon
- 100 rubber bands
- 100 beans
- 100 pennies
- 100 pipe cleaner pieces cut 1cm
- Radio/CD player, source of music (optional)

Vocabulary

Adaptation
Habitat
Bill

Birds, like the long-billed curlew or the lesser yellowleg, move their bills into and out of the mud or sand like a sewing machine needle. They have beaks designed to catch food, like worms and clams, hiding at certain depths underneath the mud or the sand. Those with longer bills are able to probe into the mud or sand more deeply than those with shorter bills. Many of these birds have bills supplied with lots of nerves. These nerves allow the birds to sense prey with their bills. Birds that use their bills to probe (search) the mud and sand are called probers.

(Insert Figure 4.6.1 Longbill Bird)- Jenny

Insert Figure 4.6.2 Western sandpiper-Jenny

Birds with relatively short bills that search for animals with their eyes and then pick them out of the mud or out of the sand are called pickers. Western sandpipers and black-bellied plovers are both pickers. Pickers, like probers, typically feed on benthic (bottom-dwelling) invertebrates.

Insert Figure 4.6.3 Black-bellied plover - Jenny

Bird with long legs, long necks, and sharp bills are grouped as the long-legged waders. These birds are designed to move into deeper waters than the probers and pickers and to catch prey, like fish and invertebrates, moving beneath the water's surface. Egrets, herons, and stilts are all long-legged waders.

Some birds sit at the surface of the water and then dive down into the water to find their food. Some, like the common murre, use their wings to propel them through the water. These birds typically have small, stiff wings and streamlined bodies. Their stiff wings allow them to "fly" through the water, yet they don't work well in the air. Other birds, like the cormorants and grebes, use their feet to propel themselves under water. Their webbed feet are designed to push water efficiently and are located near the rear of the bird. The webbing and rear placement of the feet allows the birds to push efficiently through water, but hampers movement on land. In fact, some species of grebe are unable to walk at all.

Only those birds able to successfully find food are able to reproduce and pass on their genes to their offspring. As genes are passed from one generation to the next, successful adaptations are passed along too! By taking time to look closely at birds, you can see an entire world full of adaptations in action.

Birds and Their Bills

Activity Procedure

1. During a break, set stations up around the room. Meet as a group before starting the exercise.
2. Ask students what they know about birds: What is a bird? What are some birds you have seen? Students have likely seen a sea gull, pigeon, or a robin. What is a common feature all birds have in common? Wings, bills, feathers. Do all birds look alike? Write their ideas on the board. Big, small, dark, light, colorful, plain.
3. Display the bird poster and have students guess bird diets by looking at their bill shape.
4. Tell students: Instead of teeth and lips, birds have bills as tools to catch and eat food. You can guess what kind of food a bird eats by looking at the kind of bill it has. Nuts, worms, crabs, fish, and bugs are likely bird foods.
5. Introduce "bill" utensils and compare them with the birds and bills they represent. Tell students to use utensils to see what kind of food they can pick up. Let them experiment for awhile with their "bills."

   "Bill" Utensils
   - Chop sticks = pipers, curlews etc. (probers)
   - Tweezers = warblers, bushtits, plovers, insect and small crustacean eaters (gleaners)
   - Spoons = ducks (dabblers)
   - Clothespins = finches, sparrows (seed eaters)

   "Food" items and what they represent
   - Rubber bands = worms
   - Pennies = clams
   - Beans = seeds, acorns, nuts
   - Pipe cleaners = insects or algae
5. Divide the class into groups of four and start one group at each station. Using Figure 4.6A as an example, show students how to create a data collection chart to record their observations.
6. Using Figure 4.6A as an example, show students how to create bar graph to display their data. The bar graph will have the four bill types along the bottom axis, and the number of food pieces picked up along the vertical axis (see example below). Teacher Tip: Remind students to include a legend on their bar graph to indicate what foods the different colors represent.
7. Give groups five minutes to make their chart and graph.
8. Give each student one paper cup (to represent a bird's stomach) and one bill utensil.
9. Tell students their goal is to use their utensils to try to pick up the different foods and put them in the paper cup. Each student in the group has a different kind of "bill" utensil.

Journal Prompt Closing Activity

As a class, have each group present their bar graph. Ask students some questions to get them thinking:
How did the feeding go?
Were there any surprises?
Was it easier to catch a certain type of food?
Which bill types worked best for feeding on many different types of food?
Which bill types could live together in the same habitat without competing for the same food types?
In their journals, students may write about what kind of bird they would like to be, and what bill type they would like to have.

Birds and Their Bills

Activity Extensions

1. Students may conduct research on local birds, discovering what they eat and what kind of bill type they have.

2. Have each student investigate one bird. In a group discussion, students answer these questions from the context of their bird:
- Do the bill types match the food?
- Are there any surprises?
- Where do the foods occur, and where do the birds occur?
- Do any of the foods grow in areas that are becoming harder to find?

3. At the end of the group discussion, tally up the habitats the birds are most dependent upon.
- Do the birds depend upon one habitat more than the others?
- Is this a habitat that is in danger of disappearing?

4. Discuss what may happen to the birds if the habitat is reduced, or changed so much that it no longer supports the plants the birds depend upon.

5. Conduct the bird survey from 4.2. Wetlands Exploration, around the school site or on a walking field trip of the neighborhood.

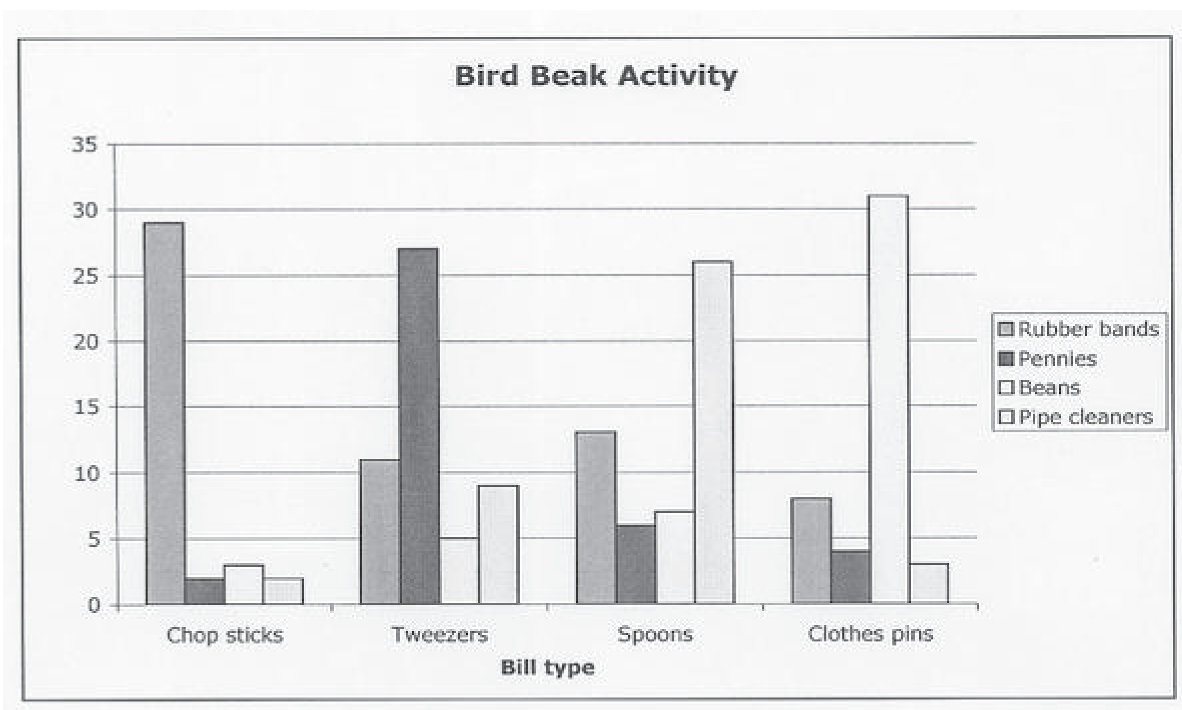
10. Before starting the timed competition, give students these instructions:
    Birds may take turns trading with group members to use different bills with each new food, or stick to the same bill for each new food type introduced
    - Birds must pick up food using only their bills and put the food in their stomachs (cups)
    - Food items may not be scooped or thrown into the stomach. Bills only! No hands!
    - Be respectful of other birds—no pushing or shoving. No elbows.
    - Birds eat for two minutes
11. At the end of two minutes, count and record the number of food pieces you have in your cup. Write your results on the data collection chart. Then we will do another food.
12. Tell students to wait for the signal to begin. Pour out one food bag in the center of each group, one food at a time. Then, give the start signal. Teacher Tip: Use music as a timer. When the music plays, students will "forage" for two minutes. (Lights switched "on" and "off" may also be used as a timer.) After two minutes, give the stop signal.
13. Have students tally up the number of food items in their "stomach" then pour the food items back on the table.
14. Change "bill" utensils, and play the game again.
15. Repeat for each of the four food types. When all four foods have been sampled, have the students count the number of "food items" they have in their cups and record them on the data sheets.
16. Help students fill in their bar graphs using the results from their data chart.

(Adapted from Elkhorn Slough Teaching Kit, Beaks and Feet: An Introduction to Bird Adaptations)

Data Collection Example

	Chopsticks	Tweezers	Spoons	Clothes pins
Rubber bands	29	11	13	8
Pennies	2	27	6	4
Beans	3	5	7	31
Pipe cleaners	2	9	26	3

Bar Graph Example



Life Between the Tides

LESSON 5.1

Summary

Students view short internet clips and look at pictures of tides to understand what causes tides, learn how to read a tide table, and make a graph from a tide table. Students look at photos taken from tidepools and learn to identify organisms and where they live. This classroom activity can stand alone or be used to prepare students for a tidepool field trip (Lesson 5.4).

Learning Objectives

Students will be able to:

- Identify how the moon affects tides
- Read a tide table and describe the diurnal tides along California's Central Coast
- Identify the zones where intertidal organisms occur

Background

The rocky shore community exists at the junction of the land and the sea, creating intertidal habitats that vary by their depth, degree of wave action, and exposure to air and sunlight. One of the richest, most varied environments in the ocean, the rocky shore is also one of the rarest ecosystems in the world. In the Monterey Bay National Marine Sanctuary, the rocky shore makes up about half of the Sanctuary's shoreline. Understanding, protecting and conserving the rocky shore community and its diverse habitats is an important job of the Sanctuary.

The periodic rising and falling of the ocean's surface water is caused by the gravitational pull of the sun and moon on the earth. The sun is much larger than the moon, but the moon is 400 times closer to the earth than the sun. Because the moon is much closer to the earth than the sun, it exerts a stronger "pull" on the water than the sun. When the moon and the sun are in line with one another, their combined forces pull strongly on the water. We have our highest and lowest tides, called spring tides, during full and new moons when the sun, the moon, and the earth are in line with one another. When the sun and the moon are at right angles of one another, their forces partially cancel each other. We have less variable tidal ranges, or neap tides, during these periods. Because the planets are constantly in motion, the tides change over time.

The rotation of the earth, moon, and sun also influence the tides. The moon rotates around the earth every 28 days and the moon and the earth rotate around the sun every 365 days. On the side of the earth nearest the moon, the moon's gravity is strongest and pulls the water towards the moon creating a bulge of water. On the other side of the earth, away from the moon, centrifugal force pushes water away from the moon creating a bulge. High tides occur where there are bulges. Low tides occur where there are not bulges.

Duration

Graphing the Tides video clips and discussion: 20 minutes
Graphing the Tides worksheet: 15 minutes
Rocky Intertidal Organisms Mural: 60 minutes

Teacher Prep

1. Read activity background
2. Photocopy Graphing the Tides worksheet, one for each student
3. Photocopy Between the Tides (mural templates), one per group
4. Cut four pieces of two foot by four foot poster paper
5. Separate out intertidal species cards
6. Gather crayons, colored pens and tape for mural

Life Between the Tides

LESSON 5.1

Materials

- Computer to view internet clips on tides (digital projector optional)
- Elkhorn Slough tides photo sequence
- Graphing the Tides (student worksheet)
- Graphing the Tides (teacher copy)
- Tide books (one for every four students, but if possible one per student)
- Between the Tides (student worksheet)
- Between the Tides (teacher copy)
- 2’ X 4’ pieces of butcher paper
- Crayons or colored art pens
- Sanctuary Species Cards

Vocabulary

High Tide
Low Tide
Neap Tide
Tidal cycle

Because the earth rotates, a given point on land travels “underneath” two tidal bulges each day and most places on earth have two high tides and two low tides each day. The area of land in between the highest high tide and the lowest low tide is called the intertidal.

Because gravitational forces and centrifugal forces influencing tides are predictable, you can use a local tide table or tide book to view the predicted time and height of high and low tides for a coastal area.

Organisms living in the rocky shore community are divided into habitat zones – the splash zone, upper intertidal zone, the middle intertidal zone, and the low intertidal zone. These organisms are impacted twice a day by the rising high tide and the retreating low tide. Learning about the tides helps us understand the challenges these organisms face in their habitats.

Activity Procedure

Graphing Tides

1. If you have access to the internet and a digital projector, show the following video clips on tides to your class: http://www.learningdemo.com/noaa/lesson10.html and http://ebiomedia.com/downloads/Tides.mov.

2. Show students the Elkhorn Slough tides photo sequence and discuss the meaning of the photos based upon their new knowledge of the tides.

3. Divide the class into groups of 4 students. Find the tide book included in your teacher’s kit, or get a copy of the current year’s tide book. Photocopy the page for the current month, and distribute to each group (or make an overhead copy). Help them learn to read the chart by asking the following questions:
   - Where is the date and time of low tides and high tides for today?
   - How many low tides and high tides are there for each day? (Usually 2 lows and 2 highs, although some days only have 1 high or low tide).
   - Why do you think the moon phase is shown on the tide chart (the moon phase influences the tides).
   - When are the lowest tides of the month, when are the highest?
   - What phase of the moon coincides with the lowest and highest tides?

- Distribute Graphing the Tides worksheets to students and explain that they will graph the tides for the day. On the X axis (horizontal), show them how to make a 24-hour timeline, starting with 12:00 am (midnight), proceeding to 12:00 pm (noon) and ending with 12:00 am (midnight). Using the examples provided on the worksheet, help them graph the tides for the day. You can also practice graphing tides for several days of the week on the graph, showing how the tidal cycle shifts daily. Use different colored pencils for each day.

Rocky Intertidal Organisms

Making a tidepool mural and placing species cards

1. Divide the class into groups. Hand out a Between the Tides Mural Template to each group. Read aloud with students the information on the back of the worksheet (What Zone Are You In?). Teacher Tip: You may name some of the species listed on the back of the teacher worksheet master to give students examples of the kinds of animals living in each tidal zone.

2. Give to each group one 2' X 4' piece of butcher paper and crayons. Tell students to place the paper tall rather than wide, and to use Between the Tides Mural Template as a model to draw their tidal zones. Before they begin, tell them to decide as a group if they want to use a ruler to lightly pencil in a grid and then have each student draw in their own square. Give students enough time to complete their diagram.

3. While the students are drawing their tidal zone murals, divide the intertidal species cards into piles.

4. Once their mural sections are done, have students take turns bringing their tidal zone mural piece up to the front of the room and tape them to the blackboard.

5. Review each zone with students and have them describe some of the conditions each go through with the rise and fall of the tides. Use the back of the mural templates as a guide.

6. After students have completed the mural and taped it to the blackboard, give one pile of species cards to each group. Each group will read over the descriptions on the back of their card, decide in which zone their species might belong, and tape their species on the mural. Teacher Tip: Remind students the zone furthest away (inland) from the water, the spray zone, gets very little water. The zone closest to the ocean, the low intertidal, is underwater most of the time. So, for example, a fish would not be placed in the spray zone.

7. If you need to take down the mural or use the species cards for another activity, hav groups write down all predicted species on the worksheet for their tidal zones. Teacher Tip: Keep these worksheets for students to use after the field trip.

8. Soon after this activity, do Activity 5.4. Tidepool Explorations. You will use this mural again for the activity extension.

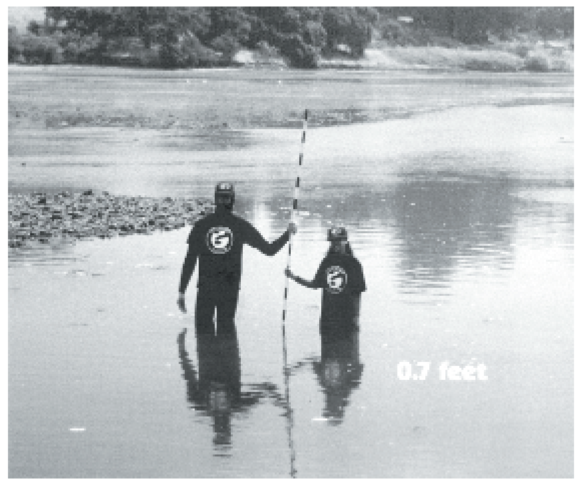
Journal Prompt Closing Activity

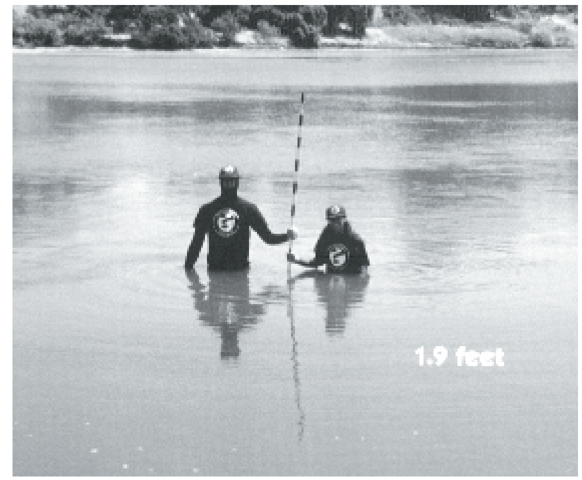
Based on their experience with the sandy beach mural, have students create a mural of the rocky intertidal community. Have them use the information on the species cards and handout to write descriptive "info cards" next to their drawings and give examples of adaptations they use to survive.

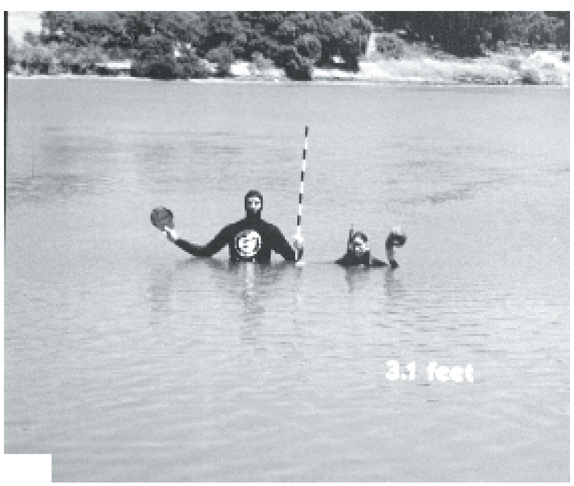
Activity Extensions

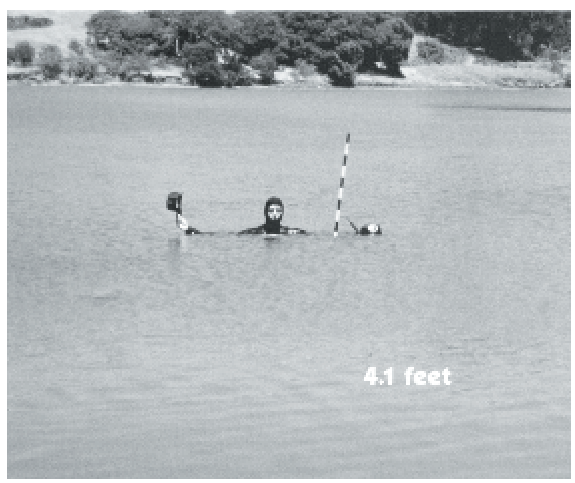
Assign a species card to each small group. Their assignment is to create a skit, poem, song or story about that organism, and act it out to the rest of the class. The skit must include the organism and an adaptation that helps it survive. Students can be actors portraying the nouns in the story; or they can create a rhyming song, make puppets, or make pictures from colored paper illustrating the organisms and water.

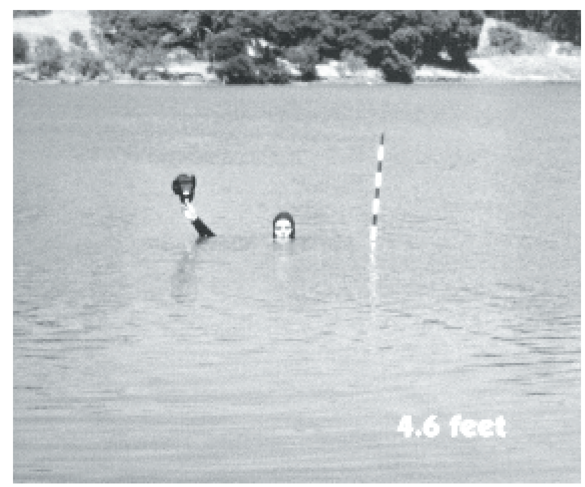
A Day With the Tides











Graphing the Tides

Graficando las Marea

LESSON 5.1

Instructions/ *Instrucciones:*

1. In the tide book, look for today's date and graph the tides in the space below.
   En el libro de mareas, encuentra la fecha de hoy y haz una gráfica en el espacio de abajo.

2. Label the axes: horizontal x-axis = Time of Day, vertical y-axis = Height of Tide.
   Tip: Watch for minus signs!
   Marca los ejes: el eje horizontal = Hora de Día, el eje vertical = Altura de Marea.
   Aviso: ¡Observa los signos de menos!

3. Mark the AM low tide height on the graph.
   En la gráfica marca la altura bajamar de la maóana (AM).

4. Mark the AM low tide height on the graph.
   En la gráfica marca la altura bajamar de la tarde (PM).

5. Mark the AM high tide height on the graph.
   En la gráfica marca la altura pleamar (o marea alta) de la maóana (AM).

6. Mark the PM high tide height on the graph.
   En la gráfica marca la altura pleamar (o marea alta) de la tarde (PM).

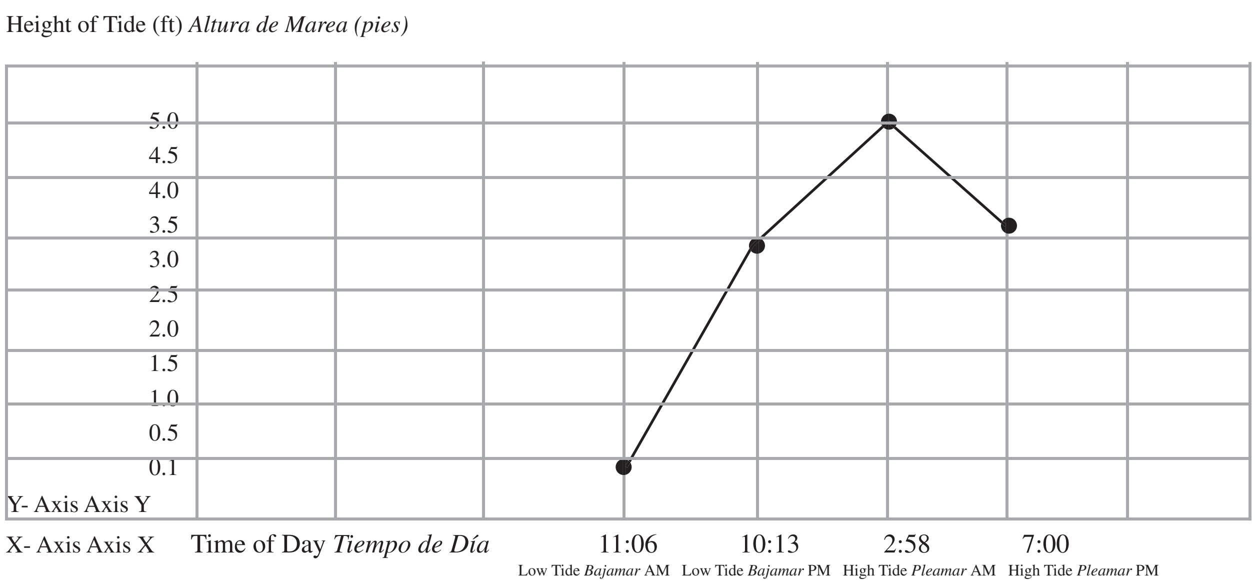
7. Connect the four points with a curved line. Look at the example on the back of the page.
   Conecta los cuatro puntos con una línea. Mira el ejemplo al otro lado de la página.

When is the best time to visit the tide pools? (Remember, you need sunlight to see where you are going!)
¿Cuando es el mejor tiempo para visitar las pozas intermareales?(¡Recuerda que necesitamos la luz del sol para ver por donde caminamos!)

Example / *Ejemplo:*

Tides for Monterey, CA for April 4, 2006

Mareas para Monterey, CA en 4 abril 2006



Graphing the Tides

Teacher's Guide

LESSON 5.1

Reading A Tide Table

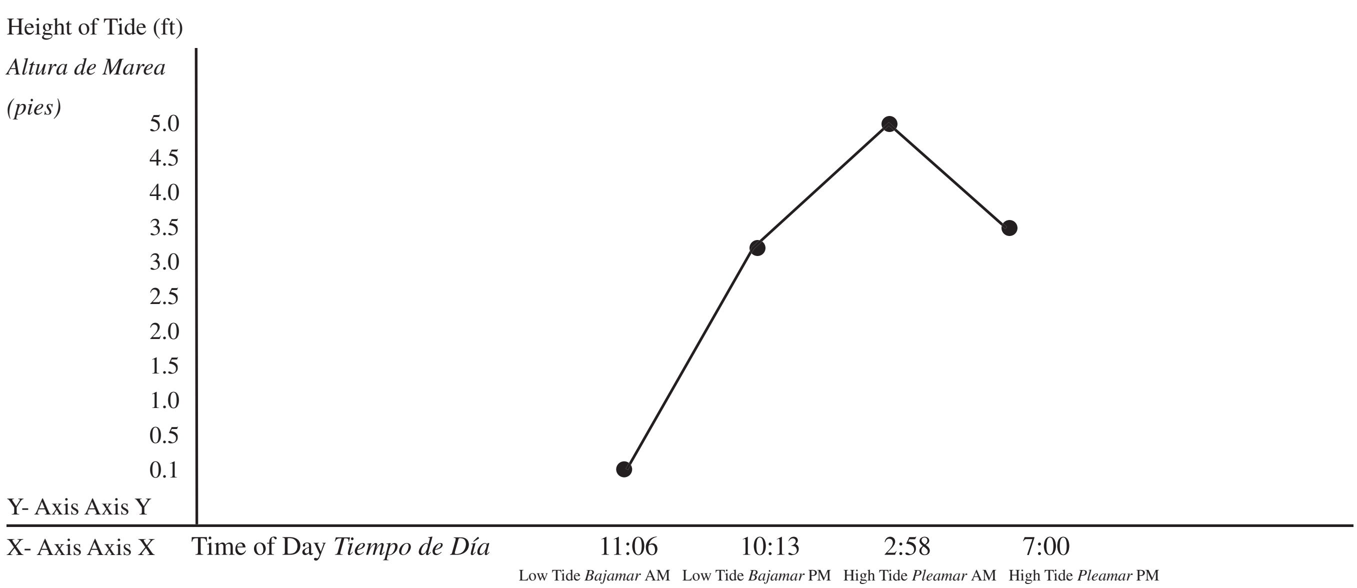
1. Hand out a tide book to each student or to each group. Explain that people use up to 400 different types of information to predict daily tidal times and heights. Tide books or tide tables have important information. They tell us what time the sun rises and sets and when the moon is full. (Tip: a full moon has the strongest pull on the tides, and the lowest and highest tides occur when the moon is full.)
2. Ask students to open their tide books. Explain that in Monterey there are two low tides and two high tides everyday.
3. Tell students to go to the first day of the month. To keep track of where they are, they can place a ruler below the day.
4. Ask students: At what time is the lowest tide of the day? At what time is the highest tide of the day? Tip: the minus sign before a height is very important. This means it is below a zero tide (a "minus tide"). Zero tide is at sea level. A minus tide is the lowest the tide can go; the more minus a tide is (the bigger the minus number), the more rocks and tide pools will be exposed.
5. Ask students: When is the best time to go visit the tide pools? (Remember, you need sunlight to see where you are going!)

Graphing the Tides

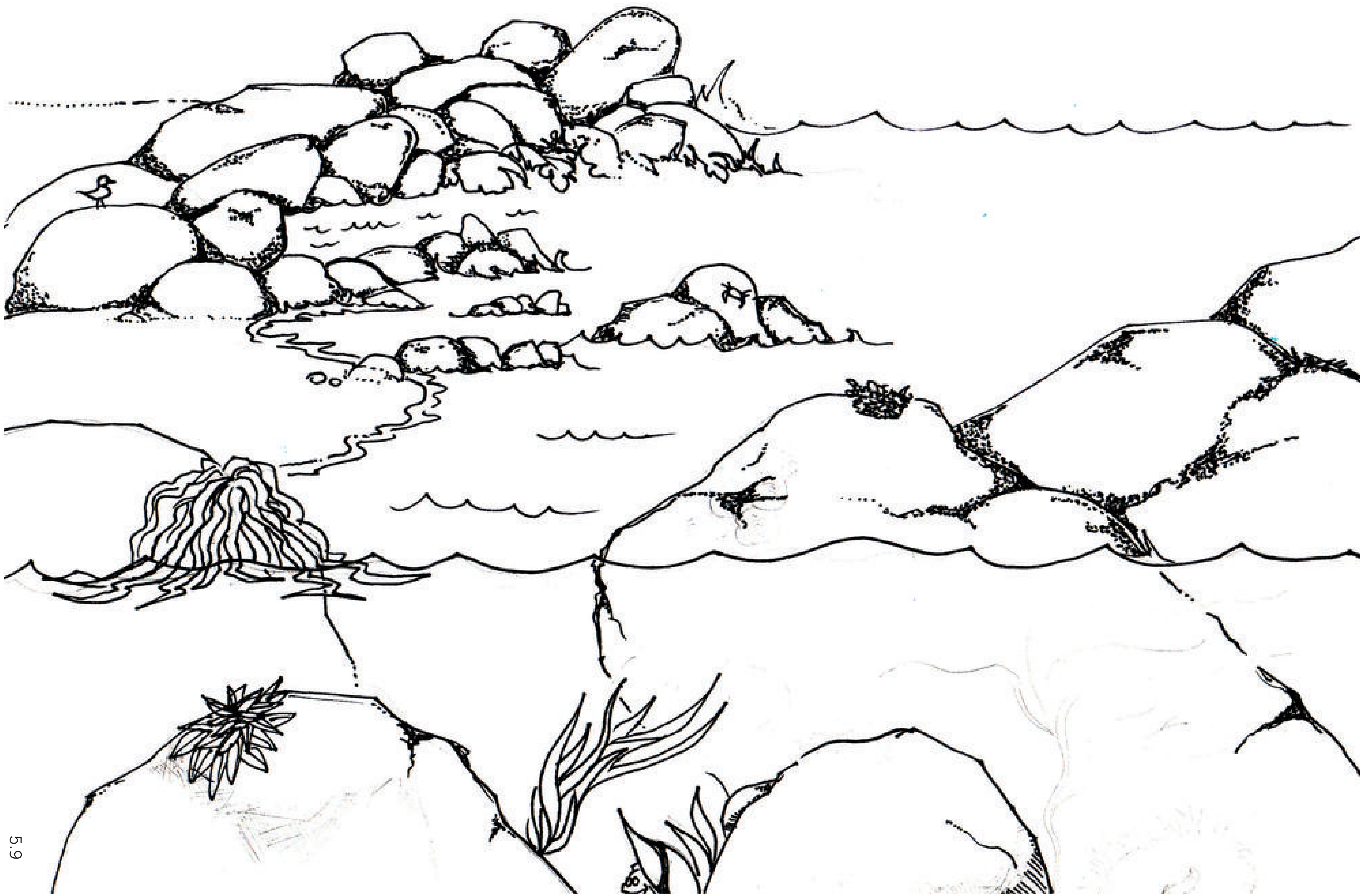
1. Tell students to look for today's date in the tidebook.
2. Tell students to label the axes on their graphs. The horizontal x-axis = Time of Day, and the vertical y-axis = Height of Tide. Remember to watch for minus signs!
3. Mark the AM low tide height on the graph.
4. Mark the AM low tide height on the graph.
5. Mark the AM high tide height on the graph.
6. Mark the PM high tide height on the graph.
7. Connect the four points with a curved line like the example below.

   Example / *Ejemplo:*

   Tides for Monterey, CA for April 4, 2006 *Mareas para Monterey, CA en 4 abril 2006*



Between the Tides Mural Template



Between the Tides / *Entre Mareas*

The intertidal zone can be divided four subzones that are characterized by the amount of time each area is exposed to air and water. / *La zona intermareal se puede dividir en cuatro zonas horizontales dependiendo de cuánto tiempo cada área esta expuesta al aire y agua.*

1. Spray Zone

The spray zone is out of the water almost all the time. It is covered with water only during the highest of high tides. The plants and animals that live here need the saltwater spray from waves, but most of them could not survive long being underwater.

Zona (Salpicadura)

La zona aerosol está fuera del agua casi todo el tiempo. Sólo está cubierta con agua durante las más altas de las mareas altas. Las plantas y los animales que viven aquí necesitan el rocío de las olas del mar, pero la mayoría de ellos no podrían sobrevivir mucho tiempo bajo el agua.

2. High Intertidal Zone

The high intertidal tide zone is out of the water most of the time and covered with water only during high tides. Plants and animals living here can live in air or water but have a harsh life because they can be in burning sun or crashing waves for long periods of time.

Zona Intermareal Alta

La zona intermareal alta está afuera del agua la mayoría del tiempo y cubierta de agua durante las mareas altas. Las plantas y los animales que viven aquí pueden vivir en aire o agua, pero tienen una vida muy difícil porque están bajo el ardiente sol o las rompientes olas por largos periodos.

3. Middle Intertidal Zone

The middle intertidal tide zone is usually covered and uncovered twice each day. The many different kinds of plants and animals living here spend more time under water than in air. Some animals can move into the low intertidal zone.

Zona Intermareal Media

La zona intermareal media usualmente está cubierta con agua y fuera del agua dos veces al día. En esta zona hay mucha diversidad de diferentes tipos de animales y plantas que pasan más tiempo bajo el agua que expuestos al aire. Algunos de estos animales se pueden mover hacia la zona inferior.

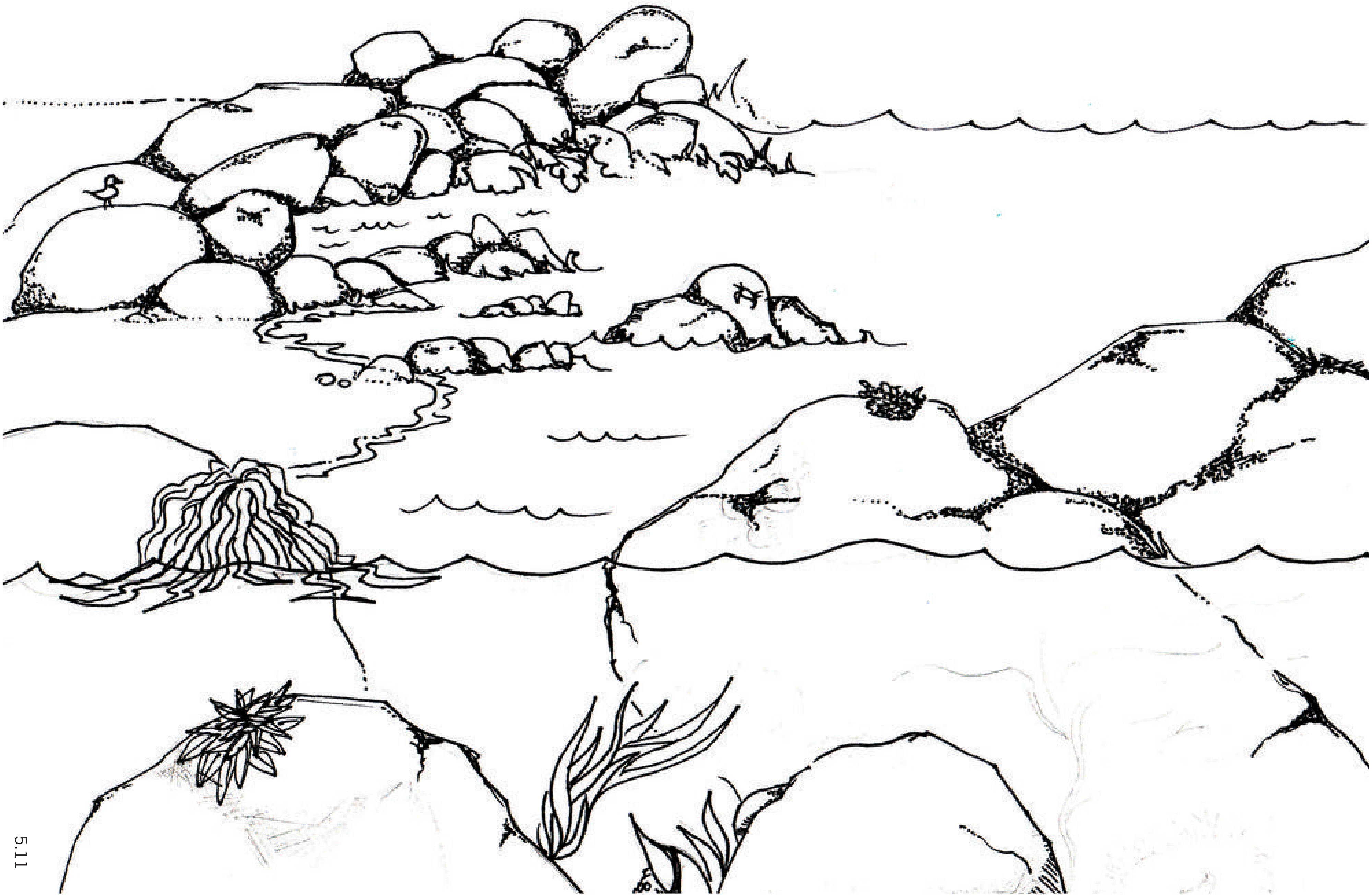
4. Low Intertidal Zone

The low intertidal zone is exposed to the air only for a few hours each month during minus tides. Many plants and animals that live here cannot live in a higher tide zone because they need to be underwater most of the time. They would dry out and die if left out in the open air for long.

Zona Intermareal Inferior

La zona intermareal inferior solo está expuesta al aire unas horas al mes durante las mareas mas bajas (o negativas). Muchos de los animales y plantas que viven aquí no pueden vivir en las zonas más altas porque necesitan estar debajo del agua la mayoría del tiempo. Sí se quedan fuera del agua por mucho tiempo se morirían.

Between the Tides Mural Template



Between the Tides (Teacher's Guide)

The intertidal zone can be divided four subzones that are characterized by the amount of time each area is exposed to air and water.

1. Spray Zone

The spray zone is out of the water almost all the time. It is covered with water only during the highest of high tides. The plants and animals that live here need the saltwater spray from waves, but most of them could not survive long being underwater.

Examples of species that inhabit this zone:

Acorn barnacle (*Balanus spp.*)
Periwinkle (*Littorina spp*.)
Ribbed limpet (*Lottia digitalis*)
Sand crab (*Emerita analoga*)

2. High Intertidal Zone

The high intertidal tide zone is out of the water most of the time and covered with water only during high tides. Plants and animals living here can live in air or water but have a harsh life because they can be in burning sun or crashing waves for long periods of time.

Examples of species that inhabit this zone:

Turkish towel (*Chondracanthus exasperatus)*
Hermit crab (*Pagurus spp.*)
Owl limpet (*Lottia gigantea)*
Lined shore crab (*Pachygrapsus crassipes*)

3. Middle Intertidal Zone

The middle intertidal tide zone is usually covered and uncovered twice each day. The many different kinds of plants and animals living here spend more time under water than in air. Some animals can move into the low intertidal zone.

Examples of species that inhabit this zone:

Black turban snail (*Tegula funebralis*)
California mussel (*Mytilus californianus*)
Giant green anemone (*Anthopleura xanthogrammica*)

4. Low Intertidal Zone

The low intertidal zone is exposed to the air only for a few hours each month during minus tides. Many plants and animals that live here cannot live in a higher tide zone because they need to be underwater most of the time. They would dry out and die if left out in the open air for long.

Examples of species that inhabit this zone:

Arrow goby (*Clevelandia ios*)
Bat star (*Asterina miniata*)
California sea cucumber (*Parastichopus californicus*)
Purple sea urchin (*Strongylocentrotus purpuratus*)

What Zone Are You In?

LESSON 5.1

The Spray Zone

The uppermost "spray zone," is out of water almost all the time, covered completely only during the highest of high tides. Only a few hardy animals, and no large algae, can endure the heat and dryness here. A few smaller algae species, such as sea lettuce, can be found in the spray zone in the winter when wave splash and rain are plentiful. During the spring and summer, this zone dries out and the algae die. Tiny diatoms (single celled protists) carpet the rocks in a brown layer that feels slippery when wet. Periwinkle snails and their relatives, limpets, slide along the rocks rasping off and digesting the diatoms as they go. Crab-relatives resembling flattened pill bugs called isopods also live here. Like periwinkles and limpets, isopods graze on diatoms growing on rocks. Isopods must keep their breathing structures moist, but cannot survive underwater.

The High Tide Zone

The high tide zone is located on the higher reaches of rocks and is covered by water only during high tides. Hardy seaweeds, like rockweeds and the nail brush seaweed, first appear here. Seaweeds and animals living in the high tide zone spend most of their time out of water and must be able to tolerate long periods of exposure to air. Many organisms living here have body designs or behaviors that help them to stay moist. Animals living in the high tide zone take refuge under the seaweed found here; seaweed provides cover from the drying sun and retained moisture for animals hiding beneath. Barnacles live in the high tide zone. Barnacles have special plates they press tightly together to keep water inside and trapped near their bodies. Only during high tides do they open these plates and extend the feathery legs they use to capture tiny organisms living in the water. Black turban snails and anemones first appear in this zone. Turban snails close a door to their shell to keep moisture near their bodies when the tide goes out. Anemones aggregate in crevices or pools where water gets trapped when the ocean retreats.

The Middle Tide Zone

The middle tide zone is generally covered by seawater and then exposed to air two times each day. Unlike the splash and high tide zones where only a few different kinds of animals can survive, the moisture-laden middle tide zone abounds with different types of organisms. Mussels are found in the mid-tide zone in great numbers. Small crabs, baby sea urchins, and a number of different worms live among the web of fibers that mussels use to attach to rocks. Moving towards the ocean, algae become more diverse and more numerous. The large, brown alga called feather-boa kelp (named for its resemblance to a long, frilly scarf) first shows up here.

The Low Tide Zone

The low tide zone dries out only during the lowest (minus) tides of the month and organisms living here primarily experience the underwater world. These organisms cannot tolerate much exposure to air. Abalone, an algae-eating relative of snails, and sea urchins and sea cucumbers, both close relatives of seastars, are frequent residents here. Sponges and tunicates color the rocks in reds, yellows, organges, whites, and purples. Although very different types of creatures, sponges and tunicates both make their living filtering tiny food particles from the water. You can often distinguish a sponge from a tunicate by touch; sponges often feel more felt-like than the slippery, rubber-like tunicates.

Waves and Sand

LESSON 5.2

Summary

Students learn how to tell the difference between tides, waves, and currents and how they influence life on the edge of the ocean. Students first view a 20-minute video about how sand moves and beaches are created. Then, they create their own beaches and sand dunes with tubs, sand, and water. These activities address two physical processes shaping Sanctuary habitats: waves and sand movement.

Learning Objectives

Students will be able to:

- Define waves, currents, and rip currents and how they are created
- Name three differences between a winter beach and a summer beach
- Know what sand is made of, and how it forms beaches and sand dunes
- Describe where sand goes in winter
- Describe how sand travels underwater along the coast

Background

The Earth's weather patterns are primarily influenced by the rotation of the earth. Because the earth spins, anything traveling over its surface gets moved to one side rather than moving in a straight line. Imagine trying to draw a line across a spinning CD or DVD. The line would be curved because as the pen moved across the surface of the disk, it moved in a circular direction. North of the equator (the Northern Hemisphere), winds and currents get pushed to the right. South of the equator, winds and currents get pushed to the left. This phenomenon is called the Coriolis Effect. The Coriolis Effect influences air and water currents and combines them into large, circular systems called gyres. These gyres create major ocean surface currents, influencing water flow throughout the world's oceans.

Insert Diagram 5.2A Major Ocean Surface Currents

Duration

LearningDemo.com:
15-20 minutes per section
Ocean in a Pan: 30 minutes (As a teacher demonstration: 10 minutes)
The Seasons of Beaches: 10 minutes

Teacher Prep

1. Based on the time you have available, you can do Ocean in a Pan as a teacher demonstration or as a student hands-on activity. It is recommended that students do the activity.
2. Gather materials.
3. Photocopy Ocean in a Pan Instructions, one per group.
4. Photocopy The Seasons of Beaches, one per student.

Waves and Sand

LESSON 5.2

Materials
- Computer
- Ocean in a Pan Instructions
- Seasons of Beaches Student worksheet
- Rectangular pans or plastic bins (9 to 12 inches deep, more than 12 inches long) one for each group of four students (or just one if you are doing Ocean in a Pan as a teacher demonstration)
- All-purpose sand (bag from hardware store)
- Two-cup container (to transport sand to the pans)
- Tap water
- Pitcher for water
- Straws, one per student
- Rulers, one per group of four students (wave makers)

Vocabulary
Beach
Coriolis Effect
Current
Sand
Tide
Wave
Weather
Wind

Journal Prompt Closing Activity
Ask students to write a short story about a grain of sand and how it got to the ocean (beginning with a trip down a river as a rock). Have students list some of the local streams, rivers and creeks that are likely sources of their sand grain.

Currents are defined as the flow of air or water in a specific direction. The horizontal movement of water is generally referred to as a water current. Air currents flowing over the water responding to changes in atmospheric pressure are called wind. Winds push against the surface of the ocean and create surface water currents.

Most waves are generated by wind blowing over water surfaces pushing the water in the same direction. The speed and duration and distance of the wind influence the amount of water it moves. Slight winds move surface waters. Faster winds blowing for long periods of time can move larger bodies of water many feet deep. As the mass of moving water approaches the shore, the deeper part of the water mass meets land or rock before the surface waters. As the "bottom" of the wave slows, water moves upward, causing the rest of the wave to increase in height and "tower up," eventually "breaking" or falling over.

Hidden from sight beneath the water's surface, millions of tons of sand move along the Sanctuary coast each year. The evidence for this sand movement is found on our beaches. Sand enters the ocean every year in the form of rocks and soil washed down creeks and streams during winter rains. Winter storms churn large waves that drag sand from beaches and keep sand particles suspended in the water. Instead, sand settles farther offshore in deeper water where waves are not breaking. This process generally results in a loss of beach sand in the winter. During the summer slower and smaller waves pick up sand from shallow depths and carry it onto the beach, resulting in an increase of beach sand during the summer.

Activity Procedure

Learningdemo.com

1. Allow students computer time to visit http://www.learningdemo.com/noaa/ to learn about ocean currents, waves and tides.

2. Ask students to review Lesson 8: Ocean Currents.

3. Ask students to review Lesson 9: Ocean Waves.

4. Ask students to review Lesson 10: Tides.

Ocean in a Pan

1.Tell students they will create their own beaches and sand dunes with tubs, sand, and water.

2. Divide students into groups of two to four.

3. Hand out Instructions for Creating an Ocean in a Pan, one tub, carton of sand, straws (one per student), and one ruler to each group.

4. Read over the instructions with students before they begin.

5. As students do this activity, walk around each group and check for understanding by having them explain to you what is happening to the water, and how they think it relates to the ocean. Use the information from the Background section of this lesson to check for understanding.

6. To clean up, have students find a place on campus to pour the water and sand outside (check with the principal or maintenance department). Or if you plan on re-using the sand for other activities, have students pour as much water off as they can, and place the sand in a shallow tray in the sun. The rest of the water should evaporate in a few days (unless it is raining!).

The Seasons of Beaches

1. Hand out The Seasons of Beaches worksheet to students.

2. Have students fill in their worksheets and discuss their answers as a class.

3. Ask students whether they would prefer to go the beach in summer or winter. Why?

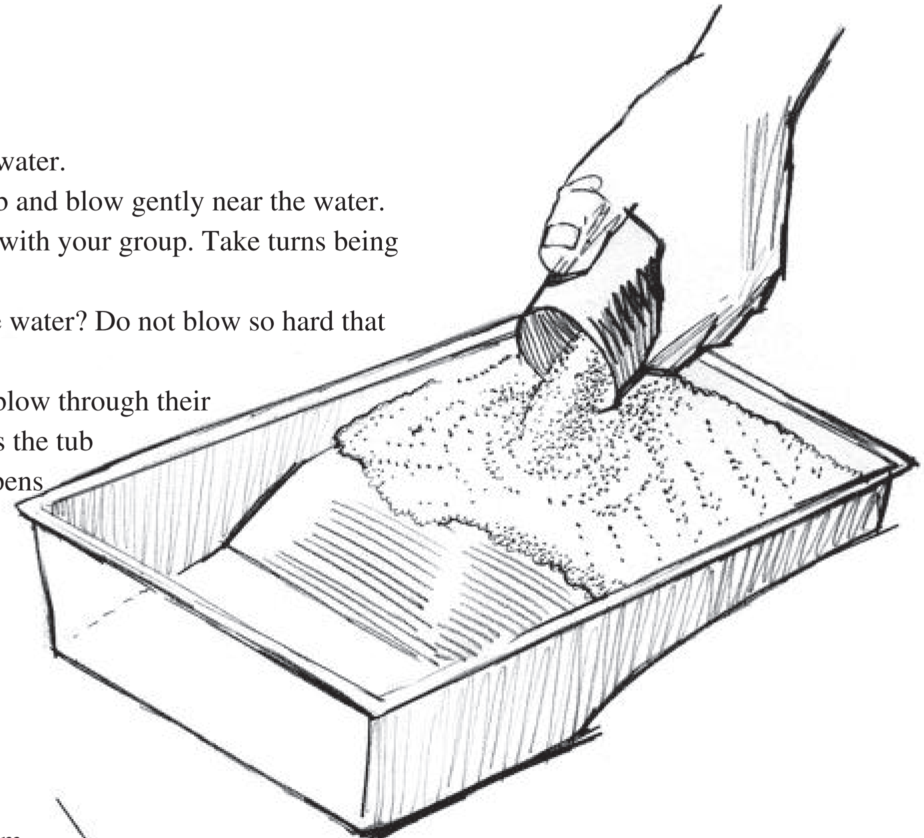
Activity Extension

Sand Study: Using hand lenses, students investigate and take notes on the characteristics of different sand samples from the sanctuary, rivers, and wetlands. Compare the colors, smells, size of grains, and how the sand feels when rubbed between your fingers. Take a close look at the grains with a magnifying lens.

Dune Walk field trip: A field trip to the sand dunes is the best way to witness the natural features creating dunes—sand and wind! Students take their journals along on a walk through the dunes, recording vital statistics (i.e. temperature, wind, cloud cover, etc.) and observations of sand dune life. While in the dunes they will find a quiet place to reflect on their observations by writing a poem or drawing a sketch.

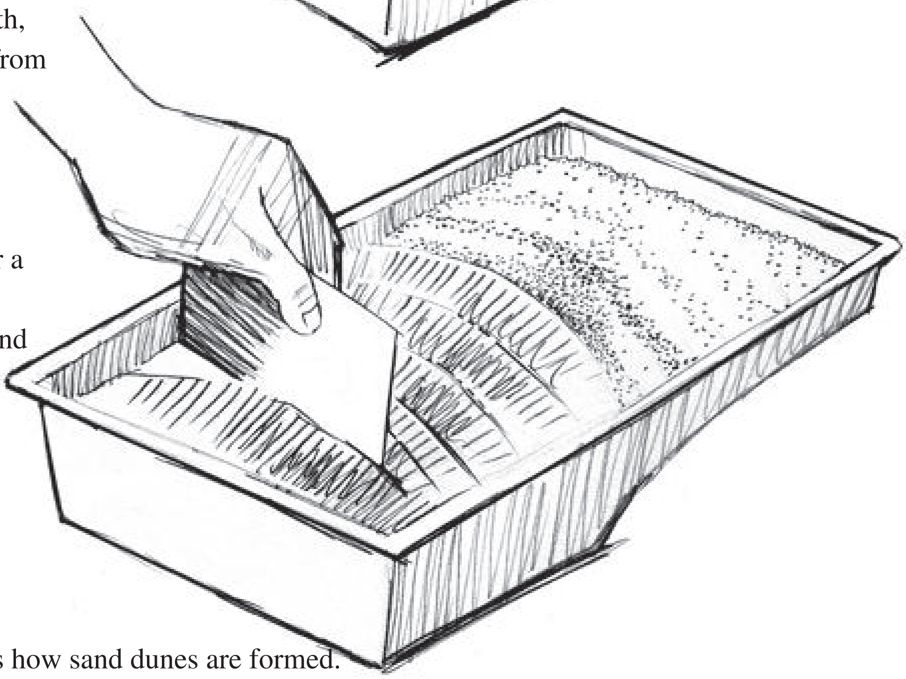
Read a sand story (recommended: On Sandy Shores, Great Explorations in Math and Science (GEMS), Lawrence Hall of Science, U. C. Berkeley, 1996. Page 55, Sandy's Journey to the Sea).

Instructions for Creating Ocean in a Pan



Creating Open Ocean Waves:

1. Fill your tub one-third of the way with water.
2. With a straw, stand at one end of the tub and blow gently near the water. What happens with the water? Discuss with your group. Take turns being the "wind."
3. Now, blow harder. What happens to the water? Do not blow so hard that water comes out of the tub.
4. Have one person stay in one place and blow through their straw while another person slowly turns the tub clockwise for three seconds. What happens to the water and the direcction of the "wind"? Though the wind hasn't changed where it is coming from, the waves are now hitting a different side of the tub. This is what happens when the wind and the rotation of the earth combine. Along the central coast, the wind blows from the north to the south, but the surface currents flow mostly from the east to the west. This is known as the Coriolis effect.



Creating Beach Waves:

1. Pour out the water to start again. Pour a cupful of sand into one end, covering about one-third of the bottom of tub and about half-way deep. Shape the sand to form a flattened rectangle at one end of your pan. Keep the sand dry.
2. Blow on the sand through your straw. What happens to the sand? Does all sand move equally? If there are some grains that are smaller than others, they should move more easily. This is how sand dunes are formed.
3. Carefully pour two to three cupfuls of water into the empty end of the pan. The water should come up to the edge of the sand, but not cover it (just like the summer beach!).
4. Find something to make waves, like a flat ruler or a notebook and practice making waves in your pan. Push the water towards the beach, gently and repeatedly, and make many small waves the same size.
5. Talk this over with your partners: How do small waves affect the sand on the beach? Using the same method, make bigger waves.
6. Talk this over with your partners: How do bigger waves affect the sand on the beach?

Ocean in a Pan activity modified from California Coastal Commission's "Beach in a Pan" from Waves, Wetlands and Watersheds, 2003, p.40-42 & Monterey Bay Aquarium's "Beach in a Pan" ©Monterey Bay Aquarium Foundation, 2000.

The Seasons of Beaches

Las Estaciones de las Playas

These are pictures of the same beaches at different seasons of the year. In the summer, gentle waves move sand up the beach. In the winter, big waves wash sand off the beach.
Estas son fotos de las mismas playas en diferentes estaciones del año. En el verano, las olas tranquilas suben la arena hacía la playa. En el invierno las olas cubren la arena y mueven la arena hacía el mar.

Label each beach, summer or winter. *Nombra cada playa, verano o invierno.*

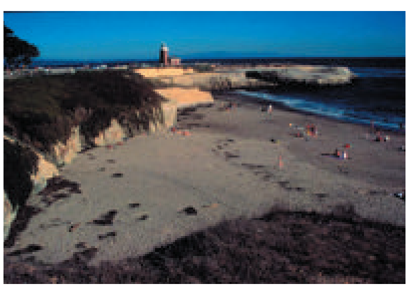
Look for things that are the same in both pictures. *Busca cosas iguales en las dos fotos.*

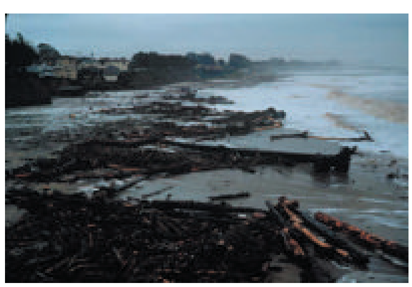
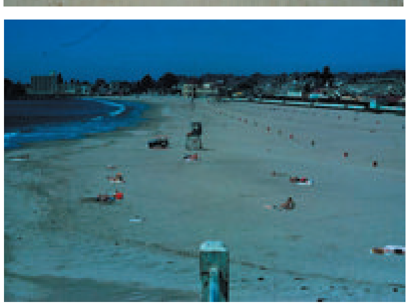
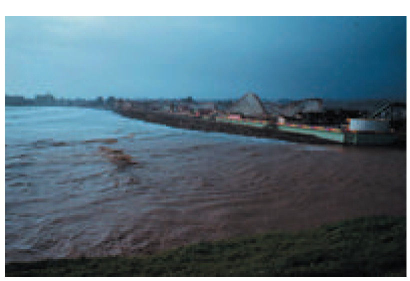
Describe a summer beach. *Describe una playa de verano.*

Describe a winter beach. *Describe una playa de invierno.*

Where does the sand go in winter? *¿Adonde va la arena en el invierno?*

Summer **Winter**



Images courtesy of Gary Griggs, University of California, Santa Cruz.

The Season of Beaches

Las Estaciones de las Playas

Answer Key

These are pictures of the same beaches at different seasons of the year. In the summer, gentle waves move sand up the beach. In the winter, big waves wash sand off the beach.

Estas son fotos de las mismas playas en diferentes estaciones del aóo. En el verano, las olas tranquilas suben la arena hacía la playa. En el invierno las olas cubren la arena y mueven la arena hacía el mar.

Label each beach, summer or winter. *Nombra cada playa, verano o invierno.*
Refer to pictures below for correct labels.

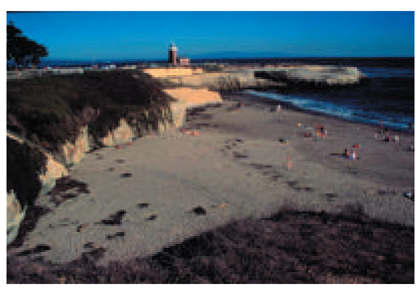
Look for things that are the same in both pictures. *Busca cosas iguales en las dos fotos.*
Students should be able to identify landmarks (i.e. boardwalk, lighthouse, coastline) in each pair of matching pictures.

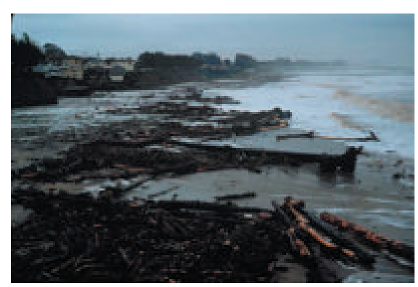
Describe a summer beach. *Describe una playa de verano.*
Summer beaches have large wide sandy areas.

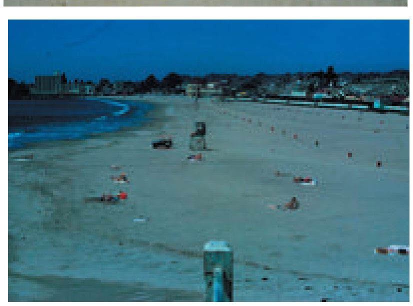
Describe a winter beach. *Describe una playa de invierno.*
Winter beaches often have no sandy beach. If a sandy beach does exist, it is much smaller than the summer sandy area and is often covered with debris that has been left by crashing waves.

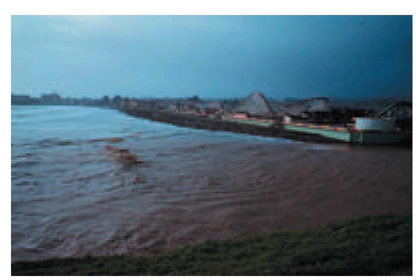
Where does the sand go in winter?
¿Adonde va la arena en el invierno?
Big winter waves pull sand off beaches and deposit it offshore in underwater sandbars.

Summer | **Winter**









Images courtesy of Gary Griggs, University of California, Santa Cruz.

Sand Crab Monitoring

LESSON 5.3

Summary

Students view a presentation about their upcoming sand crab monitoring field trip to learn what sand crabs eat, what eats them, how to size them, how to determine gender, how to lessen trauma when collecting them for study, and why they are monitoring sand crab populations. In the field, students work in groups to collect sand crabs and gather measurements on each crab before releasing them. After monitoring sand crabs, students return to their classroom to graph their results and compare them with data collected over the years from different schools.

Learning Objectives

Students will be able to:

- Conduct field studies using standardized monitoring procedures
- Graph their data
- Describe their hands-on knowledge of sand crabs: habitat requirements, what they eat, who eats them, how to size them, how to determine gender, and how to lessen trauma when collecting them for study

Background

The sandy beach is not an easy place to live. Unlike the rocky intertidal ecosystem, there is no solid material on which to attach. Animals have to deal with crashing waves, changing tides, beaches that change seasonally, and marine and terrestrial predators.

Despite their barren appearance, beaches are full of life. Many animals, like worms, clams and sand crabs are difficult to see because they live beneath the surface of the sand. Burrowing helps protect these animals from predators, waves, drying sun and extremes in temperature and salinity. Most burrowing beach animals either filter tiny plant and animal plankton from the water (filter-feeders) or eat debris from the sand (deposit-feeders).

Sand crabs migrate up and down the beach with the tides to stay in the right spot to feed. Burrowing just beneath the sand, sand crabs face up the beach and extend their feathery antenna into the water to trap plankton. Filter feeders, such as sand crabs, are at the base of their food chain. They can be directly affected by pollution and studied as indicators of environmental health. The common sand crab can be monitored over time to reveal changes in ecosystem health. They have also been used to indicate levels of toxins in the waters off of California. Domoic acid is a neurotoxin produced by diatoms, a type of phytoplankton. When sand crabs eat the toxic plankton they become toxic to birds, otters, and fish that eat them. Monitoring of habitats or species is essential for helping us better understand marine ecosystems, and evaluate the health of our oceans.

Duration

Classroom Preparation:
15-20 minutes
Sand Crab Field Trip:
1.5 hours plus travel time
Closing Activity:
30-60 minutes

Teacher Prep

1. Contact the Sanctuary's MERITO staff at least one to two months prior to arrange field trip date and location.
2. Arrange for transportation and permission slips.
3. At least one week before the field trip, review this list of appropriate clothing with students: sturdy shoes that can get wet, a windbreaker, sunscreen, hat, pants that are easy to move around in, suggest a change of clothes (at least pants and socks).

Sand Crab Monitoring

LESSON 5.3

Materials

- Sand Crab Monitoring slide show and appropriate viewing equipment
- Sand Crab Monitoring equipment (provided by the Sanctuary's MERITO staff)
- About Sand Crab Handout, one per student (optional)
- Sand Crab Monitoring Data Sheet, one for each group
- Appropriate clothing for beach field trip
- Graphing your Data worksheet, one for each group

Vocabulary

Carapace
Pleopods
Sand Crab
Telson

Scientists and resource managers use monitoring data to make decisions about how to best protect or manage our natural resources.

Activity Procedure

Teacher Tip: This cooperative learning activity requires students in a group to have different roles. Prepare the class by assigning roles: recorder, transect layer, sample collector and measurer. The recorder is responsible for recording the data on the data sheet. The transect layer is responsible for laying the transect correctly. The sampler collects the sand sample, and the measurer measures the sand crabs, reporting the numbers to the recorder. Have students rotate so everyone gets to try each role.

Classroom Preparation

1. Show students the Sand Crab Monitoring slide show. Discuss the important role sand crabs play in the food chain. Filter feeders like sand crabs are important links in food chains, and pollution can directly harm them. Scientists study animals like sand crabs to determine the health of their ocean habitat. Some of the things scientists want to include: What is their abundance? What proportion of the population is female/male? How many females have eggs? What is the distribution of sand crabs across the beach? How does the beach community change over a year? Scientists and resource managers use information from studies like these to make decisions about how to protect our oceans and preserve healthy ecosystems.

2. Review handouts "About Sand Crabs" to learn about their anatomy and natural history. Look at the Sand Crab data sheet and protocols from the slide show, so that students are well prepared for the field trip and talk to students about ocean safety (in Appendix).

Sand Crab Monitoring at the Beach

3. MERITO staff will meet you at the beach to give instructions and guidelines on how sand crab monitoring is done and show students how to measure a sand crab and identify its gender.

4. Students will work in groups and report their observations on a Sand Crab Monitoring Data Sheet. MERITO staff will share with students the most current data collected at that site and discuss some factors that may influence their findings:

Journal Prompt Closing Activity

- Back in the classroom, students will graph their sand crab monitoring data results.
- Have students get back into their sand crab monitoring groups and hand out their Sand Crab Monitoring Data Sheet and a Graphing your Data Worksheet to each student.
- Explain to students that they will graph their sand crab data results, making one graph for each of their findings: size frequency, gender frequency and distribution along the beach. If students need help with their graphs, tell them to refer to the graphing example on the back of their worksheet.

Activity Extensions

If you wish to do an in-class activity before or after you take your students to the beach, you can download sand crab activities from: http://limpets.noaa.gov/welcome.html

About Sand Crabs

The Pacific mole crab *(Emerita analoga)*, also known as the sand crab, is a common inhabitant of the sandy beach. It lives in the swash zone of the sandy beach intertidal zone along the Pacific coast from Alaska to Baja California in the northern hemisphere and between Ecuador and Argentina in the southern hemisphere. Because the swash zone changes with the tide, so does the location of sand crabs.

Sand crabs are small in size (35 mm long and 25 mm wide), gray or sand colored and have no claws or spines. Like other crustaceans, it periodically molts, and empty exoskeletons (the external body covering) may be found on the shore. Males and females look very similar at first glance, but there are some major differences. Females have a larger carapace length of 14 to 35 mm, while the males reach 10 to 22 mm. If a female is carrying eggs, they will be a bright-orange mass found under the telson (the middle lobe of the tail folded under the body). If a female is not carrying eggs, the pleopods (the limbs attached to the abdomen) to which she attaches eggs will be visible on the underside of the crab when the telson is lifted. There are three pairs of pleopods, and they resemble short threads.

A pacific mole crab spends most of its time buried in the sand. It has five pairs of legs that allow it to swim, crawl, and burrow, which are all done backwards. Its eyestalks reach above the sand. The first pair of antennae reach above the sand for respiration, and the second pair, resembling feathers, are extended when the crab feeds. The antennae collect small organisms, mostly dinoflagellates (a single celled planktonic protist), then they are pulled into the body, and the food is scraped off.

Pacific mole crabs resemble another species of sand crab that live along the shore, the spiny sand crab, *Blepharipoda occidentalis*. This crab lives deeper in the subtidal zone and can reach 6 cm in length. Adult spiny sand crabs feed on dead sand crabs.

Natural History

Sand crabs are usually found on the beach in large numbers from spring to fall. In the winter, storms carry them offshore into sandbars. When the sand is transported back onshore in the spring, the crabs come with it.

During the reproductive season (February-October), females can produce one clutch per month of 50-45,000 eggs, which take approximately 30 days to develop. Once the eggs hatch, the larvae are planktonic for about 4.5 months. They go through 8-11 larval stages, and during this time may drift far offshore. When they near the end of their larval stage, they hopefully return to nearshore waters. When the larvae settle onto the beach, it is called recruitment, and the crabs are considered ìrecruits.î Recruitment can occur year-round, but large numbers of recruits are found in early summer and in the fall. The crabs move up and down the beach with the tides. Crabs move when water rushes over the sand. Crabs also move down the length of a beach with longshore currents. As a wave returns to sea, it takes sand and crabs with it and when the next wave goes in at an angle farther down shore it deposits the crabs in a new location.

About Sand Crabs

The crabs form large aggregations along the shore that are not uniformly spaced. Scientists have proposed biological reasons for this, such as predator avoidance and an advantage for mating. Physical reasons, such as water flow and wave shock, have also been proposed. A combination of multiple factors may explain the aggregations. The number of crabs on a beach can vary drastically from year to year, depending on environmental factors.

Predators and Parasites

A sand crab's primary predators are fish and birds. Fish are a greater threat, which may explain why sand crabs are mostly in the upper intertidal zone. Barred surfperch are common fish in the surf zone and sand crabs have been found to make up 90% of their diet. Shorebirds, including sandpipers, sanderlings, godwits, blackbellied plovers, willets, and curlew, have been seen feeding on crabs within the swash zone. The surf scooter, a water bird, also feeds on sand crabs and sea otters are mammalian predators of sand crabs.

Sand crabs are known to carry parasites. They are an intermediate host of parasitic worms. These parasites are passed onto the predators of sand crabs. Sea otters and birds can eat many crabs per day, and the ingested parasites have been known to kill these predators.

Modified, with permission, from the Pacific Mole Crab FACT Sheet produced by the Farallones Marine Sanctuary Association and the Gulf of the Farallones National Marine Sanctuary.

Sand Crab Monitoring Data Sheet

Beach name ______________________________

Date ______________________________

Random Location # __________

School name ______________________________

Team Members ______________________________

____

____

Record the gender and size of each crab. Use these codes: F=female FE=female with egg M=male R=recruit (< 9mm)
Also note any crabs that have a soft shell by adding SS.
An example would be: for a 22 mm female with eggs = FE 22
If you start in the water, begin with sample #10; if starting on the shore, begin with sample #1.

Sample Number								Tally
Circle a zone:								
Dry or Swash								
Sample Number								
Circle a zone:								
Dry or Swash								
Sample Number								
Circle a zone:								
Dry or Swash								
Sample Number								
Circle a zone:								
Dry or Swash								
Sample Number								
Circle a zone:								
Dry or Swash								
Sample Number								
Circle a zone:								
Dry or Swash								

Sand Crab Monitoring Data Sheet

Beach name ______________________________

Date ______________________________

Random Location # __________

School name ______________________________

Team Members ______________________________

____

____

Record the gender and size of each crab. Use these codes: F=female FE=female with egg M=male R=recruit (< 9mm)
Also note any crabs that have a soft shell by adding SS.
An example would be: for a 22 mm female with eggs = FE 22
If you start in the water, begin with sample #10; if starting on the shore, begin with sample #1.

Sample Number								**Tally**
Circle a zone:								
Dry or Swash								

Sample Number								
Circle a zone:								
Dry or Swash								

Sample Number								
Circle a zone:								
Dry or Swash								

Sample Number								
Circle a zone:								
Dry or Swash								

Sample Number								
Circle a zone:								
Dry or Swash								

Sample Number								
Circle a zone:								
Dry or Swash								

Graphing Your Data

Graficando Tus Datos

Student name/ *Nombre:*____

Date of sand crab monitoring/ *Fecha de monitorización de pulgas de arena:* ________________

Beach site name/ *Playa:*____

Use the data your group collected during your sand crab monitoring field trip to fill in the three graphs below. Look at the examples on the back if you need help.

Utilice los datos que tu grupo recogió durante tu monitorización de pulgas de arena para llenar las tres gráficas abajo. Mira los ejemplos al fin de la página si necesitas ayuda.

Graph 1: Sand crab distribution in the swash zone (number of crabs in each flag sample).

Gráfica 1: Distribución de pulgas de arena en la playa.

Graph 2: Frequency of sand crab sizes *Gráfica 2: Frecuencia de largo de pulgas de arena.*

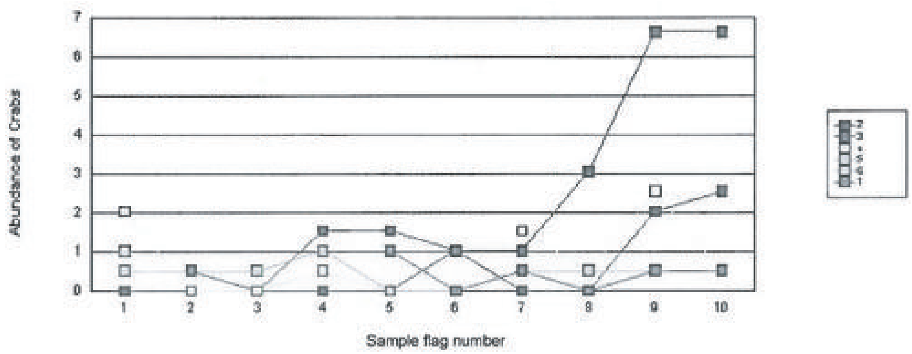
Graph 3: Frequency of sand crab gender *Gráfica 3: Frecuencia de género de pulgas de arena.*

Graphing Example

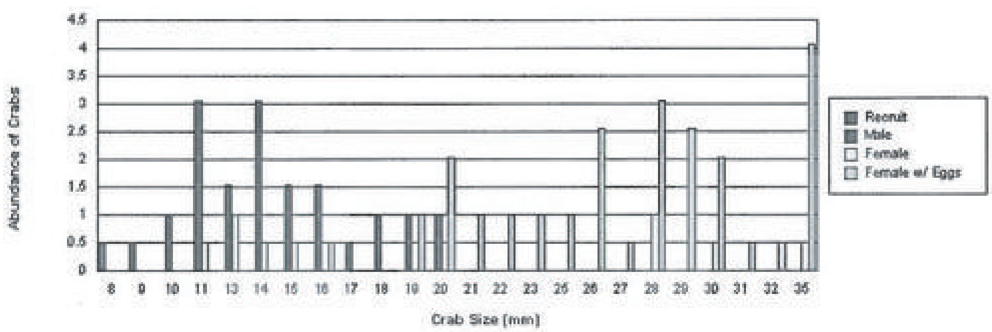
Ejemplo de Gráficas

Graph Title: Sand Crab Monitoring at Seaside State Beach, CA on May 12, 2005
Título: Monitorización de pulgas de arena en la Playa de Seaside, CA en 12 mayo 2005

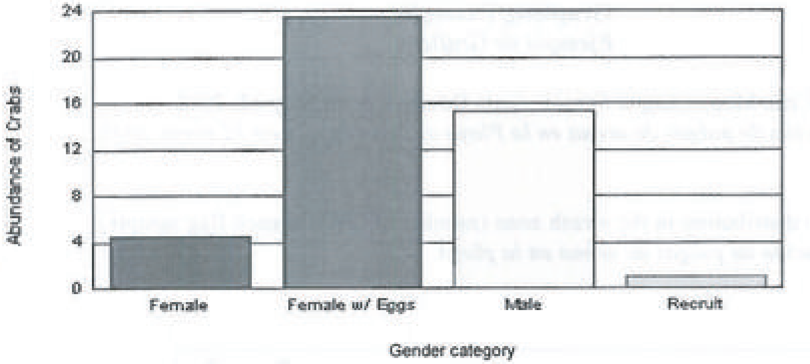
Graph 1: Sand crab distribution in the swash zone (number of crabs in each flag sample)
Gráfica 1: Distribución de pulgas de arena en la playa.



Graph 2: Frequency of sand crab sizes
Gráfica 2: Frecuencia de largo de pulgas de arena.



Graph 3: Frequency of sand crab gender
Gráfica 3: Frecuencia de género de pulgas de arena.



Tidepool Explorations

LESSON 5.4

Summary

Students take a field trip to the coast to learn about rocky intertidal communities and habitats. Once in the intertidal area and armed with Tidepool Identification Keys, students break into small groups to explore the four different tide zones. As a wrap-up, the class discusses adaptations of species in the different zones.

Learning Objectives

Students will be able to:
- Identify intertidal organisms they see
- Describe the intertidal zones and adaptations of two animals who live in them
- Teach tidepool and ocean etiquette to others

Background

The intertidal community is a beautiful and exciting place. It offers tremendous opportunities for learning about the natural world, stimulates thought and creativity, and can offer lifetime experiences for those who visit.

The Monterey Bay National Marine Sanctuary has a responsibility to protect natural resources and habitats while encouraging safe and responsible use and enjoyment. Because the rocky shore is so accessible, it is vulnerable to human disturbance, including trampling or displacement of organisms and the collection of marine life, shells or rocks. To reduce the impact of visitors to this special area, review these guidelines with your class before going on the field trip:
- Learn before you go. To get the most from your experience, learn about tidepools and the organisms who live in them before you go. Check on locations, regulations and tides, and use the internet or field guides to help you learn about seashore life.
- Step Lightly. Most rocks are covered with living animals and algae. Step carefully to avoid crushing animals or algae.
- Look closely. Sit quietly and watch for a few minutes. You'll see and learn much more this way.
- Touch gently. If you touch an animal or algae, touch it gently.
- Leave everything as you find it. Strict laws govern the collecting of intertidal life. Enjoy seashore life in its natural environment and leave the plants and algae exactly as you found them.
- Share your knowledge with others. Speak up if you notice other visitors behaving in a way that disturbs tidepool life.

Duration

Tidepool explorations:
60 minutes plus travel time from school
Closing activity: 10 minutes
Extension: 30 minutes

Teacher Prep

1. Contact MERITO staff at least one month in advance to arrange a field trip date and location. Please keep low tide in mind when considering possible dates.
2. Arrange for transportation and permission slips.
3. Have the class do Activity 5.1. Life Between the Tides before you do the field trip, to become familiar with the definitions of intertidal zones.
4. Review with students the list of appropriate clothing for a tidepool field trip: lace-up shoes or boots that can get wet, hat, sunscreen, wind breaker, layered clothing

Tidepool Explorations

LESSON 5.4

Materials

- Proper clothing for students for tidepool field trip: lace-up shoes or boots that can get wet, hat, sunscreen, wind breaker, layered clothing
- Whistle
- Tidepool Identification Key (provided in kit)
- Magnifying containers (provided in kit)

Vocabulary

Adaptation
Ocean Safety
Tidepool Etiquette

Journal Prompt Closing Activity

Back in the classroom, hold a small discussion with your students using the following questions as prompts:

- Were there similarities between animals living in the same tidal zone? What were they?
- Did you find some plants and animals living in more than one tidal zone? Which ones?
- What were the main differences you saw between the zones (amount of water, algae, different kinds of rocks, etc.)?

Ocean Safety:

- Plan well. Tides of 0.0 or lower are best for viewing tidepool life. Check your local tide book to select the best day and time for tidepooling.
- Dress for weather. Weather along the coast can be highly variable. Dressing in layers is a good idea.
- Dress for safety. Rocks and algae can be slippery. Wear shoes with good traction.
- Watch the waves and keep an eye on the ocean. Before you go down to a tidepool, watch the waves to see where waves are crashing. Once at the tidepool area, always keep an eye on the ocean; rogue waves can be unpredictable and deadly.
- Carry a first aid kit. Even the most safety conscious can get scrapes and scratches during a tidepool visit.
- Careful field trip preparation will help to ensure a safe and educational tidepool visit. Careful exploration of tidepools will help ensure all creatures, including people, can continue to benefit from the bounty of tidepools.

Activity Procedure

1. It is recommended that you do Activity 5.1 Life Between the Tides, before you go on this field trip. It will prepare students for what they will be experiencing, and give them ideas of what to look for. Review descriptions of tidal zones from Activity 5.1, What Zone Are You In? Review Ocean Safety Tips and be sure students wear good shoes, bring a jacket, and know the rules. Teacher Tip: Do not allow students to roam any further than they can hear the whistle.

2. When you arrive at the tidepool location, MERITO staff will meet you in the parking lot and talk briefly with the entire class.

3. Break students into groups of four, and hand out one Tidepool Identification Key and one quadrat to each group. Students may take turns holding the key and being the recorder.

4. The Sanctuary's MERITO staff person will assist you in designating where students are allowed to go. Groups must stay together. If the waves are big, each group designates one "wave watcher" to call out when a wave is coming close to the group.

5. Send one group of students to each of the tide zones (if you have more than four groups, two groups can go to a tide zone, just have them keep about ten feet between them). Make sure all students can clearly recognize the four zones, as they will switch locations after ten minutes.

6. Students need to find and identify at least five animals and two plants. After students have visited and gathered data, call them back together and have each group share the names and descriptions of some of the species found in the different zones.

(Journal Prompt cont.)

- How might the different conditions in each tidal zone affect the species living there?
- Explain to students these species have adaptations making it possible to live in their tidal zone. The amount of water, how long they are exposed to air and the type of substrate (rock, sand, mud) are the most important factors determining whether a species can survive in the intertidal.
- Species either adapt to their surroundings, find a new home, or die.
- Which species do you think are the most likely to be harmed by humans? Why?

Activity Extensions

Have students place a quadrat (contact MERITO staff for quadrant information) down and identify and count as many species as they can locate in the quadrat, recording their findings on the key. If they find species not on the key, students make a note describing what it looks like. You can tell students that they may move around within their zone and find other locations to place their quadrat.

Life in the Kelp Forest

LESSON 5.5

Summary

Students view a kelp forest video where they learn what kelp needs to grow, the habitats kelp creates and who lives in them, and the many ways we use kelp. A visit from the nonprofit organization Friends of the Sea Otter follows, and students learn about the natural history, ecology, and survival of sea otters, a marine mammal that has a special relationship to kelp.

Learning Objectives

Students will be able to:

- Name the kind of kelp that makes up kelp forests in the Monterey Bay
- Name three animals living in the kelp forests
- Identify two things kelp need to grow
- Describe the interrelationship of kelp, sea urchins and sea otters

Background

Near the edge of the continent lives one of the fastest growing and tallest plants on the planet-giant kelp (Macrocystis pyrifera). Lush, dense kelp forests are a distinguishing feature of the Monterey Bay National Marine Sanctuary, and one of the reasons for its designation. Where cold, clean, moderately-moving, nutrient-rich water and rocky seafloor less than one hundred feet deep are found, towering underwater forests of kelp can grow. Two types of tall-growing kelp are found in the Sanctuary. Giant kelp (Macrocystis pyrifera) forms thick forests in areas like Monterey Bay where water motion is calm. Bull kelp (Nereocystis leutkeana) is more common in areas where rough waters are found.

There are few other places in the world where forests of giant kelp and bull kelp are as lush as those in the Monterey Bay National Marine Sanctuary. The structure of kelp provides a variety of habitats, including the holdfast, stipe and canopy. The kelp forest community supports thousands of organisms and enhances the biodiversity of the entire central coast of California.

For more information about kelp, read handout About Kelp.

Duration

Kelp Matters video:
10 minutes
About Kelp Handout:
15 minutes
Friends of the Sea Otter
presentation: 60 minutes

Teacher Prep

1. Contact Friends of the Sea Otter at 831-373-2747 at least three weeks in advance to arrange a classroom presentation.
2. Set up appropriate equipment for the Kelp Forest video.

Materials

- Kelp Matters video and appropriate equipment
- About Kelp handout
- Friends of the Sea Otter educational materials from website (optional)
- Extension: Monterey Bay Aquarium Kelp Forest poster and activities (optional)

Life in the Kelp Forest

Vocabulary

Blade
Bull Kelp
Float
Giant Kelp
Holdfast
Kelp
Seaweed
Sea otter
Stipe

Journal Prompt Closing Activity

After the guest speaker has gone, follow up with the class about what they learned. Encourage them to write a haiku about a kelp forest or a community within.

Activity Procedure

1. Before the guest speaker arrives, show students the Kelp Forest video. Optional: Assign worksheet "About Kelp" as a reading assignment or read it together as a class. Have the class label the different parts of kelp in the handout.

2. Ask students: Have you ever seen a kelp forest? Where did you see it? Kelp forests occur along the coast of the Sanctuary, usually about 50 to 100 feet from shore. From shore, students would see the canopy of the kelp forest as it spreads out on the water's surface.

Friends of the Sea Otter presentation

Call Friends of the Sea Otter at (831)373-2747 to arrange a classroom visit. You may use Friends of the Sea Otter's educational materials to prepare your students before the presentation by visiting their website: http://www.seaotters.org/

1. Friends of the Sea Otter introduction: Students enter the underwater world of sea otters, learning about natural history, behavior, anatomical adaptations, foraging, tool use, survival and the importance of sea otters as a "keystone species". Students learn how to observe and study sea otters in the wild and how they can help save sea otters from extinction. Other topics include conservation, plastic pollution, cleaning beaches, recycling oil, storm drains, and calling stranding networks.

2. Feeding station: Students further explore the meaning of "keystone species" and how otters find and capture food. A sea otter skull, complete with a full-set of teeth, is used to demonstrate their adaptations to feed on armored prey. Students are shown a variety of prey eaten by sea otters and how they use tools to open them, thus demonstrating their creativity and intelligence. A biomagnification demonstration describes the effects of pollution and contaminants, and highlights their sensitive ecosystem living so close to the ocean's coast.

3. Survival station: Students learn about the anatomy of sea otters, swimming locomotion, and the process and purpose of grooming. They are shown the importance of staying warm and the dangerous effects of pollution on sea otters' fur. Students learn how they can help and their self-awareness is engaged as they discover that the survival of the sea otter depends on them.

4. Sea Otter costume: One student will be transformed into a sea otter, starting with skin and adding fur, webbed feet, arm muscles, paws with retractable claws, and a head complete with teeth, ears, whiskers, and a nose. This very entertaining demonstration addresses sea otter adaptations and their differences from other marine mammals that use blubber to keep warm, stressing the vulnerability of sea otter fur, and reinforcing their protection from pollution and other hazards in the ocean.

Activity Extensions

1. Turn your classroom into a kelp forest! Hang streamers or poster paper cut in the form of kelp, and attach them to the classroom ceiling, down to the floor where the holdfasts are attached. Have students draw and cut out kelp forest inhabitants using the MBA kelp forest poster as a model. Students tape their species in the forest canopy, stipe, or holdfast. For kelp forest poster example, visit: http://www.mbayaq.org/PDF_files/activities/aquarium_kelp_poster.pdf
2. If you want to learn more about kelp, where it is and what animals live there, visit the sanctuary's SIMoN website for maps of kelp forests in the sanctuary: http://www.mbnms-simon.org/sections/kelpForest/maps_graphs.php?sec=kf
3. The Monterey Bay Aquarium has online kelp forest activities, and additional activities you can download and do in class. Visit: http://www.mbayaq.org/efc/kelp.asp

About Kelp

Near the edge of the continent lives one of the fastest growing and tallest plants on the planet-giant kelp *(Macrocystis pyrifera)*. Giant kelp grows in dense forests that calm the water and provide habitat for many fish, invertebrates, algae, and the endangered sea otter. Giant kelp is a tall, brown alga that grows on rocky bottoms up to 100 feet deep. It has long, slender stipes (similar to stems) that stretch up to the water's surface to reach the sun. Algae do not have roots, so the giant kelp needs a rocky bottom for its holdfast (similar to roots) to attach to rocks. A unique combination of cold, clear, near-shore, nutrient-rich, deep water and a rocky bottom are critical to the survival of kelp forest habitats and the hundreds of species living in this forest.

Underwater forests comprised of towering strands of giant kelp, a type of brown algae, are a distinguishing feature of the Monterey Bay National Marine Sanctuary. Where cold, clean, moderately-moving, nutrient-rich water and rocky seafloor less than one hundred feet deep are found, towering underwater forests of kelp can grow. Two types of tall-growing kelp are found in the Sanctuary. Giant kelp *(Macrocystis pyrifera)* forms thick forests in areas like Monterey Bay where water motion is calm. Bull kelp *(Nereocystis leutkeana)* is more common in areas where rough waters are found. Forests of giant kelp and bull kelp grow from Alaska to Baja California, along the west coast of South America, and in just a few spots along the coasts of South Africa and southern Australia.

Giant kelp and bull kelp are brown algae and each is comprised of the following structures: holdfast, blades, stipe, and one or more air bladders (floats).

The holdfast
Kelp can only survive where rocky bottoms provide a location for attachment. The kelp holdfast attaches kelp to rocks using a tangled network of branch-like structures called haptera. The haptera continue to grow and intertwine as the kelp grows and the holdfast becomes a mini-habitat for creatures like brittle stars, worms, and other small creatures. Although the holdfast looks like the roots of land-plants, it is not a root structure; it does not absorb nutrients like the roots of land plants. The blades of kelp carry this responsibility!

The blades
Blades of kelp look like large, underwater blades of grass. Blades of kelp absorb nutrients from the water. Moderate water motion and the rippled surface of the blades help this process to occur. Like giant leaves, kelp blades harness energy from the sun to power photosynthesis.

The stipe
The stipe functions like a very flexible tree trunk. The stipe provides stability to the kelp while allowing it to bend and sway in response to water movement. It also carries food energy from the top of the kelp down to the bottom.

Floats
In giant kelp, a single, gas-filled float called a pneumatocyst (pronounced new-mat-o-cyst) is attached to each blade of kelp. In bull kelp, all of the blades of kelp are attached to one large pneumatocyst. In both kelps, pneumatocysts provide lift and buoyancy to the kelp and keep the kelp floating in the water column. As giant kelp grows and reaches the surface of the ocean, the blades fan across the surface of the water forming a canopy.

About Kelp

GIANT KELP *Macrocystis pyrifera*

Giant kelp is one of the fastest growing and tallest organisms on the planet. When conditions are just right, giant kelp can grow up to fourteen inches per day. Giant kelp reaches lengths of up to 100 feet. How deep kelp is found depends on how well sunlight penetrates down into the ocean. Where sunlight is able to penetrate deeply into the ocean, kelp can extend down to depths of 100 feet. Where sunlight is unable to penetrate deeply into the ocean, kelp grows in shallow areas. Because giant kelp requires rocky bottoms less than 100 feet deep, it typically grows close to shore. Wherever a kelp canopy floats just offshore, an underwater forest is present beneath the waterís surface.

Kelp forests provide food, shelter, and nursery grounds for many different types of animals. Kelp forests slow the speed of the water moving around them. By doing so, they create a zone of calm, slower-moving water. This calm water provides younger animals, like juvenile rockfish, a safe place to rest and grow.

The fast growth rate of kelp provides a steady stream of food to hungry animals. Sea urchins, abalone, and turban snails are all animals that feed directly on kelp. These kelp-eaters attract animals, like sea otters, feeding higher up on the food chain. Drift kelp, pieces of kelp that are broken off, feed organisms on the kelp forest seafloor and in other places. Drift kelp ends up on sandy beaches and on deep reefs, areas where kelp cannot grow. The drift kelps feeds organisms in these habitats too.

GIANT KELP *Macrocystis pyrifera*

Kelp forests are like apartment complexes; kelp forests offer organisms a number of different living arrangements. Some organisms like abalone, octopus, sponges, blue top snails, and brittle stars live near the bottom of the kelp forest. Some animals like worms and baby sea urchins, live inside the kelp holdfast. Other organisms, like limpets, live on the stipe. Box-like colonies of bryozoans cover kelp blades.

Kelp forests provide things for people, too. Kelp contains the chemical algin. Algin is used as a thickener in products like ice cream, toothpaste, beer, and paints. Kelp forests also attract divers desiring to explore the beauty and bounty of the kelp forest habitat.

Kelp forests rival rain forests and coral reefs in terms of the abundance of different living things found there. The variety of living spaces and abundance of food found in kelp forests makes them one of the most diverse habitats on the planet. Careful use, management, and exploration of kelp forests will help ensure all creatures, including people, can continue to benefit from the bounty of kelp forests.

Know your Kelp
Label the different parts of Kelp in this diagram.

Create a Deep-Sea Creature

LESSON 6.1

Summary

Students learn about the deep-sea conditions and the kinds of adaptations species need to survive in the deep sea. Students become deep-sea researchers, and form research groups on a mission to discover new species. Students create, illustrate, and name their own deep-sea creatures. Students then report to the rest of their fellow scientists and share their discoveries with the rest of the class.

Learning Objectives

Students will be able to:

- Name three challenges to survival in the deep sea
- Name three adaptations deep-sea creatures can have that enable them to survive in the deep sea

Background

The deep sea is a tough place to live. It's dark, it's cold, and living things are under a lot of pressure. Because it is such a harsh and unusual place to live, deep sea organisms often exhibit unusual adaptations, body parts or behaviors that help them to survive, in response to low light levels, cold water, and high pressure.

In the deep sea there is not enough sunlight to support plant life, so food is scarce. Deep-sea organisms often have body parts that enable them to capture a meal whenever one swims by. For example, many deep-sea organisms have large mouths, highly expandable stomachs, and sharp teeth for capturing food. These body parts enable some organisms to capture a large meal item, even if it is much, much bigger than they are. Other deep-sea organisms travel to the epipelagic zone, where food is more abundant, to get a meal. These animals, like lantern fish, make nightly migrations to surface waters to feed and return to depths during the day. These migrators, with stomachs full, become a source of food to those lurking in the depths.

Because it is dark in the deep sea, many organisms produce their own light, or bioluminescence. Bioluminescence is found in most types of animals living in the deep sea-from fish to tiny copepods (small crab relatives). Scientists estimate that 90 percent of deep-sea species are bioluminescent. Some organisms produce light on their bellies as countershading, an adaptation in which organisms are darker on their backs (or on top) and lighter on their bellies. In deep-sea fishes, the belly lights are able to match the light level of the surrounding water and when viewed from below, by a predator, for example, they are difficult to see. Some organisms use bioluminescence to attract food or mates, while others use it to confuse or scare predators. In response to light level, many fish and some macroinvertebrates living in the mesopelagic zone have developed

Duration

Introduction: 10 minutes
Create a Deep-Sea Creature: 20-30 minutes
Scientific Conference (presentations): 30 minutes

Teacher Prep

1. Read activity background
2. Gather art supplies

Materials

- Grand Canyon of Monterey Bay poster
- Large pieces of paper
- Key to Common Latin Roots, Prefixes, and Suffixes (in Appendix)
- Pencils, colored pens or crayons

Vocabulary

Adaptation
Bathypelagic
Benthic
Bioluminescence
Camouflage
Countershading
Epipelagic
Habitat
Mesopelagic
Pelagic

large and elaborate eyes that allow them to see under low light conditions, while most bathypelagic fishes have eyes that are absent or reduced in size.

Temperatures in the deep sea average about four degrees Celsius, or just above freezing. It's cold down there and organisms often exhibit adaptations that conserve energy. For example, most deep-sea organisms lack heavy body parts that would take a lot of energy to produce and then move through water. Some fishes have large teeth, but they are soft, pliable and less heavy to carry than dense teeth.

Organisms in the deep sea are under a lot of pressure. Pressure increases by 14.5 pounds per square inch with every increase in 10 meters of depth. So organisms at 1000 meters (3280 feet) have over 14,500 pounds per square inch of water "weight" pressing on their bodies. Because of the great pressure, most deep-sea organisms lack air spaces, like swim bladders, inside their bodies. As a comparison, consider a human diver. Human divers rarely venture to depths over 60 meters (200 feet); the air spaces inside the lungs make it a dangerous endeavor. As divers descend down into the ocean, pressurized air from the lungs can form bubbles in the blood stream, which can lead to injury or death. Also, at very deep depths, the lungs simply cannot expand against the force of the water weight pushing against the diver's chest. Conversely, as divers rise to the surface from depth, the air inside the lungs expands. If a diver does not exhale as he or she rises to the surface, injury or death can occur.

An amazing array of weird and wonderful organisms can be found thriving in deep-sea environments. These often bizarre and strange looking organisms can be a powerful hook to engage students in the study of the deep sea. One look at a deep-sea anglerfish, a viperfish, a fangtooth, a flapjack octopus, or vampire squid is almost certain to prompt a question or two!

The Monterey Bay Submarine Canyon, sits just off the coast of central California, and provides scientists with a unique opportunity to study the deep sea on a regular basis. This underwater canyon begins its plummet to the depths of the ocean only 100 meters (328 feet) from the Moss Landing shore and reaches depths of over 3,600 meters (12,000 feet) just sixty miles offshore. Because the canyon is located just offshore, scientists like those from the Monterrey Bay Aquarium Research Institute in Moss Landing, are able to make regular trips to study deep-sea life, habitats, and processes.

Create a Deep-Sea Creature

Activity Procedure

Setting the Deep Sea Scene

1. Place the Grand Canyon of Monterey Bay poster up in front of the class.

2. Tell students: The deep seafloor goes under water from the edge of the continental shelf across broad plains and down into trenches seven miles deep. The Monterey Canyon is very deep and close to shore, so scientists can study deep-sea habitats nearby. Deep sea researchers go to sea aboard huge research vessels equipped with expensive sonar, deepwater dredges, traps, and submersible vehicles, but a complete picture of the deep sea is still years away.

3. Use the Background information from this lesson to explain the challenges of living in the deep: light, temperature, salinity and pressure. Because it is such a harsh place to live, deep-sea animals often have unusual adaptations, which can be body parts or behaviors that help them survive.

4. Look at and discuss the pictures of animals that live in the deep sea in the Grand Canyon of Monterey Bay poster. All animals are adapted to eat, reproduce, and protect themselves from predators. Here are some adaptations of deep-sea creatures:
   - Body color can camouflage or attract attention—transparent or silvery animals are difficult to see in the water column.
   - Bioluminescence, the production of light by living animals, can be used to inform, confuse or attract other deep-sea animals, or to distract predators.
   - Large, well-developed eyes to see in dim light. Many animals in the darkest depths have small, poorly developed eyes but have developed other ways of "seeing," like touch, smell, or sensitivity to movement.
   - Lightweight skeleton, weak muscles, flabby body. A deep-sea fish does not need as much food to support its small body.
   - Acute sense of smell helps a deep-sea animal find a mate in the darkness. Fish with good vision may focus on attractive lights and shapes. A hermaphrodite that can fertilize its own eggs has added insurance that it can reproduce even if it never finds a mate.

Create a Deep-Sea Creature

1. Tell students: You are going to be deep-sea scientific researchers, on a mission to discover new deep-sea species.

2. Scientists work best in groups. Break students into research groups of two to three students.

Journal Prompt Closing Activity

Have students imagine they are a deep-sea researcher and write about their deep-sea expedition, what they saw and discovered. What was the most challenging part of your deep-sea expedition?

Activity Extensions

The Monterey Bay area has over fifteen marine research institutions—one of the largest concentrations of marine researchers in the world! Arrange for a marine scientist to visit your class.

Scientists from the Monterey Bay National Marine Sanctuary, Monterey Bay Aquarium Research Institute (MBARI), Moss Landing Marine Labs, and the University of California, Santa Cruz, may be able to visit your classroom and show pictures of their undersea adventures.

Visit the Monterey Bay Aquarium and focus on their deep-sea species. Are any of them similar to the creatures your students created?

3. Hand out a large sheet of paper and art materials to each group. In their research groups, students brainstorm what characteristics their new discovery will have, use their imagination to create a colored drawing and label their creature's unique adaptations to living in the deep sea. Tell students to include the adaptations just discussed, such as body color, size, how they reproduce, and catch prey, etc.

4. Give students the Key to Common Roots, Prefixes, and Suffixes for the Latin terms (In Appendix) to use as a guide when naming their creature. Write an example to help students name their creature: The scientific name for dover sole is Microstomus pacificus. Micro = small, stomus = mouth, pacificus = of the Pacific. So it is a small-mouthed fish that lives in the Pacific Ocean.

5. Give students about 20-30 minutes to create a poster of their newly discovered deep-sea creature. Teacher tip: tell students NOT to cut out their species, as the adaptations need to be pointed out on the poster.

6. After students have created their deep-sea creature poster, bring them back together to hold a scientific conference. In a scientific conference, research groups take turns presenting their latest discoveries to the class, and take turns asking questions about the new discoveries.

7. Where did you find your new deep-sea creature?
   - How did you collect it?
   - Did you see others just like it, or do you think it is very rare?
   - Is your animal a fish, mammal, or invertebrate?
   - Is your animal pelagic or benthic?
   - What adaptations does your animal have? What are some of its parts for?

8. If you have time, have a poster session where students display their posters throughout the room. Take photographs of students standing next to their posters.

Plankton Lab at Elkhorn Slough

LESSON 6.2

Summary

On a field trip to the plankton lab at Elkhorn Slough National Estuarine Research Reserve (ESNERR), students will explore plankton under microscopes and learn their importance to the food chain. Students will also learn about the difference between zooplankton and phytoplankton, and see how even the smallest organisms in the food chain play an essential role in the ocean ecosystem.

Learning Objectives

Students will be able to:

• Understand the importance of plankton to the food chain
• Identify three different plankton using a plankton key sheet
• Establish the link between phytoplankton, zooplankton, and oceanic food chains

Background

Plants and animals living in the ocean can be grouped into two categories. Those able to swim against a current are called nekton while those unable to swim against a current are called plankton. The word plankton means "wanderer" or "drifter". This means they travel wherever the current takes them, because they lack the strength to swim against the current. Most plankton are tiny (microscopic), however there are some larger ones like jellies.

There are two large categories of plankton: plant plankton and animal plankton. Plant plankton, called phytoplankton, use the sun's energy to make their own food using photosynthesis just like plants on land. Phytoplankton in food chains, like land plants, are "producers". Producers are able to produce their own food through photosynthesis and are at the base of almost all food chains on earth (the exception being those food chains containing chemosynthetic organisms). Just as producers on land support consumers, animals that must consume food to obtain energy, phytoplankton support consumers in the ocean.

Animal plankton, called zooplankton, are animal forms of plankton that typically feed on phytoplankton. Some of these animal plankton are the larvae of animals such as crabs and barnacles. The zooplankton are identified by their size.

Plankton are quite spectacular to observe under a microscope; their varied shapes and movements reflect adaptations that help them survive and stay afloat. Some plankton spend their whole life as plankton. Others start off their lives with a larval stage as plankton and then grow into bigger animals, like sea stars, sea cucumbers, corals, lobsters and many species of fish.

Duration

Plankton Lab (at ESNERR): 20-30 minutes + travel time
Lab Clean Up: 10 minutes

Teacher Prep

1. Schedule a field trip to Elkhorn Slough by filling out the Field Trip request form (in Appendix) at least three weeks in advance. If you would like to do the Plankton Tow as well, please mark that in the form. Teacher Tip: You will need an extra hour to conduct the plankton tow.
2. Arrange for transportation and chaperones.
3. Read activity background and procedures before arriving at Elkhorn Slough.
4. The day before the field trip remind students of field trip manners and remind them to dress in layers.

Materials

• Field journals
• Plankton samples collected from Elkhorn Slough or Kirby Park (provided by Elkhorn Slough)
• Microscopes and petri dishes (provided by Elkhorn Slough)
• Plankton species ID sheet (provided by Elkhorn Slough)

Plankton Lab at Elkhorn Slough

LESSON 6.2

Vocabulary

Adaptation
Consumer
Ecosystem
Nekton
Phytoplankton
Plankton
Producer
Zooplankton

Journal Prompt Closing Activity

Create a food chain starting with phytoplankton, and explain what would happen if plankton were affected by pollution. Review with students what plankton is and why plankton so important to all of us. What type of pollution could hurt plankton?

Exploring plankton under microscopes offers an opportunity to view otherwise "invisible" tiny life forms. This illustrates how even the smallest part of an ecosystem can be extremely important to the rest, reinforcing the interconnectedness of plants, animals, and their environments.

Activity Procedure

Plankton Lab at Elkhorn Slough National Estuarine Research Reserve

1. Make arrangements for travel, chaperones, and field trip forms. Arrange your class rotation with the Elkhorn Slough staff when you submit your Field Trip request form (in Appendix). If you are doing a Plankton Tow, please read the Activity Extension section. Prepare your class for the Plankton Lab by reviewing the Background Section of this lesson.

2. When you arrive at Elkhorn Slough, divide your class in two groups, no larger than 12 students each, since there are only 12 microscopes in the lab. While one group is in the plankton lab, the other group could go for a short walk or go into the visitor center. The plankton lab will already be set up for your group to use when you arrive. To provide the best possible experience for everyone using the lab, and to help keep the equipment properly maintained, follow these guidelines:

3. Use the "Tips to See More" guide on the sample table.

4. Move people instead of samples, from scope to scope!

5. Wipe up any spilled water.

6. Please, only adults use the big microscope on the counter.

7. In order for students to become familiar with the microscopes, have them practice a few minutes focusing on the photographs first.

8. Now have students look at samples provided by Elkhorn Slough. These samples contain larger size plankton, and are easier for students to identify.

9. Using the plankton ID sheets provided in the lab, have students identify as many as possible. Be sure students also see the sample on the T.V. monitor.

10. After 15 or 20 minutes of observations (depending on your schedule), ask students to draw and label their most interesting plankton from their sample on their journal.

11. Lab Clean Up

When your group has finished with its observations, review their checklist to make sure that everything is in order and ready for the next group. If you are the last rotation within a larger group, please check off the items on the list and sign your name at the bottom of the page.

Activity Extensions

If your class has an extra hour, you can plan to conduct a plankton tow in the field. Your students can walk down to the bridge to collect their own plankton sample using Elkhorn Slough's equipment.

Plankton Tow Observations

This plankton will be much smaller in size, so students will have to do a few tricks in order to get a good look at them.

- First, pour the plankton sample in a glass bowl. Using the lamp on the table, point the light to one side of the bowl to concentrate the zooplankton, since they are attracted to light!
- Then, using a small pipette, pick up a small sample and place a drop into the middle of each petri dish (one for each microscope).
- Tell students to set their microscopes to 2X magnification and start looking for the quick moving plankton. Once they are able to focus on some, ask them to change the magnification to 4X to get a closer look.
- Remember to move people, instead of samples, from scope to scope!

Plankton Models

LESSON 6.3

Summary

Students learn about the different forms and structures (adaptations) zooplankton and phytoplankton use to help them stay afloat and survive. They choose from a list of these features to create their own plankton shape, and make up a name for their species based on the Latin root words scientists use to invent names for new species.

Learning Objectives

Students will be able to:

- Explain why certain shapes and structures (adaptations) enhance plankton's ability to survive
- Create a scientific name based on biological characteristics of an organism
- Establish the link between phytoplankton, zooplankton, and oceanic food chains

Background

Too small to see by the naked eye, marine plankton have some weird and wacky looks to them! However, as form follows function, these structures make plankton extremely successful in their floating world by enabling them to move with the light and currents to stay afloat near the surface. Without plankton the entire oceanic food web would collapse, so hurray for the weird!

Plant and animal plankton are typically found near the surface of the ocean. Sunlight penetrates only the uppermost layer of the ocean. Phytoplankton, nature's tiniest photosynthesizers, rely on the sun's energy for photosynthesis and must therefore live in sunlit surface waters. If phytoplankton were to sink down into the depths of darkness, they would no longer be able to photosynthesize and would ultimately die. Zooplankton feed on phytoplankton as a food source, and must live where they can find a meal. If zooplankton were to sink away from phytoplankton at the surface, they would starve and ultimately die. To survive, both phytoplankton and zooplankton need to stay in surface waters, and they have some rather amazing adaptations enabling them to stay afloat near the surface.

Phytoplankton and zooplankton are typically small (microscopic), and being small has its advantages when it comes to staying afloat. Organisms small in size have greater surface area compared to larger creatures. Higher surface areas slow sinking rates. Many plankton have spikes, spines and bristles to increase their surface area. Structures like these distribute a plankton's weight across a greater surface area and slow their sinking rate and retain a position in surface waters. A close look at the larvae of a barnacle or a crab will reveal an array of bristly, spine-like body parts. Other plankton

Duration

What is Plankton?:
5-10 minutes
Fashion a Plankton:
30-40 minutes
Closing Activity:
10-15 minutes

Teacher Prep

1. Read activity background
2. Photocopy Plankton Models worksheet, one per group of three to five students
3. Gather art materials (see materials list)
4. Photocopy Key to Latin Roots, Prefixes, and Suffixes, (in Appendix) one per group

Materials

- Plankton Models worksheet
- Key to Common Latin Roots, Prefixes, and Suffixes (in Appendix)
- Construction paper
- Scissors
- Ribbon
- Paper plates
- Tape
- Crayons or markers
- Stapler
- Pipe cleaners
- Clay
- Aluminum foil
- Glue
- White or colored tissue paper

Plankton Models

LESSON 6.3

Vocabulary
Adaptation
Food Web
Photosynthesis
Phytoplankton
Plankton
Surface area
Zooplankton

Journal Prompt Closing Activity
In their journals, ask students, "If phytoplankton were taken out of the food chain, describe what effect it would have on zooplankton, sea otters, sea turtles, whales, and people?" Ask students to share their thoughts.

Activity Extensions
Plankton have some of the most beautiful shapes, many only revealed through electron microscopy. Look online to get a close look at these shapes, and students can speculate how each of the shapes might help the plankton survive in surface waters. Here are some excellent websites for plankton watching:
http://www.bigelow.org/foodweb/
http://life.bio.sunysb.edu/marinebio/plankton.html
http://www-sioadm.ucsd.edu/plankton/
(Adapted from the Southeast Phytoplankton Monitoring Network, Fashion a Phytoplankton)

have oil or air-filled structures inside their bodies. Since oil and air are both lighter than water, these structures provide a buoyant lift to the organism housing them. Sometimes, plankton are named for the physical characteristics they display.

New species of plankton are provided with a scientific name, generally by the scientist making the discovery. The two-name system (genus and species) is called binomial nomenclature and is used for clarity and consistency in communication. A scientific name contains a genus name and a species name. The genus is the name given to a group of very similar species. For example, all cats that roar are grouped into the genus Panthera. Lions are called Panthera leo, tigers are called Panthera tigris, and leopards are called Panthera pardus. Species names within a genus are unique to a particular organism. Two organisms in different genus may share the same scientific name, but no organisms will ever have the same genus and the same species name. Although it is not always the case, the species name is often derived from the structures or behaviors an organism exhibits or the location where it was found. For example, California condors and the California sea lion share the same species name- californianus. The genus names, however, differ, thus providing each animal with a unique name.

Activity Procedure
1. Break the class into groups of three to five students. Review what they know about plankton by looking at the Background Section of this lesson and referring to their field trip (optional). Hand out the Plankton Models Worksheet, construction paper and art supplies to each group. Tell students they are going to work in research groups to design and name their own species of plankton.

2. Encourage creativity as students play with designs to develop a plankton that will float, based on the designs of actual plankton. A group can create more than one example if they like.

3. Once students have designed and built their plankton model, they must name it using the Key to Common Latin Roots, Prefixes, and Suffixes (in Appendix)

4. After building and naming their plankton, each group will present their plankton to the class and explain the name, characteristics, and possible purposes of the organism's structures to the class. Hang the plankton from the ceiling as an in-class art show, or exhibit them elsewhere in the school.

Fashion a Plankton

LESSON 6.3

1. **Choose** from this list of plankton characteristics to design your own plankton. DO NOT COPY them, just use these characteristics to create a different and unique plankton.

Structure or form name	What is it?	What does it look like?
Process	Long and skinny, it sticks out to the side of the plankton	*(i.e. Rhizosolenia)*
Pennate	A shape that has both halves identical, as a mirror image	*(i.e. Asterionellopsis)*
Segmented	The main body is separated into sections like a string of sausages	*(i.e. Guinardia)*
Centric	A shape that, if cut through the middle like a hamburger bun, the top half is identical to the bottom half	*(i.e. Coscinodiscus)*
Chloroplast	The organelle in phytoplankton where photosynthesis occurs	
Nucleus	The organelle where DNA and chromosomes are found	
Chain	A shape where a series of identical organisms are linked together	*(i.e. Odontella)*
Raphe	A line down the middle between two similar parts	*(i.e. Pleurosigma)*
Trough	A dent in the middle	*(i.e. Ceratium)*
Eyespot	A light-sensitive patch of pigment	*(i.e. Pavlova)*
Step-chain	Segments are linked together to form a series of steps	*(i.e. Pseudo-nitzschia)*
Plated	Armored with plates	*(i.e. Protoperidinium)*
Theca	Many layers of membranes, some have scales	*(i.e. Prorocentrum)*
Flagella	Wiggly and whip-like, they are used for moving around	*(i.e. Karenia)*
Peduncle	A mouth used to wrap around food	*(i.e. Pfiesteria)*
Spines	Solid structures that stick out from the surface	*(i.e. Chaetoceros)*
Bilobed	Divided into two lobes, or sections	*(i.e. Akashiwo)*
Frustule	A roundish shape made of silicate, like a little glass house	*(i.e. Coscinodiscus)*

2. **Sketch** your plankton showing the structures you chose to use. Get art materials to create it in three-dimensions.

3. **Name it!** Organisms have their own scientific name. It must have a genus name (capitalized) and a species name (lower case); both names are italicized. You can use the Latin root meaning of the words to name the new species you create (i.e., bi = two, so bilobed means two lobes). Names can also be based on people, region/location, shape/size/color, similarity to other species or other defining characteristics.

Diseña un Plancton

LESSON 6.3

1. **Escoge** de la lista de características de plancton para diseñar tu propio plankton. NO COPIES estos plancton, solo usa estas características para crear un plancton diferente y nico.

Nombre de la Estructura o Forma	¿Qué es? ¿Para que es?	¿Como se ve?
Proceso	Largo y delgado, sale por un lado del plancton	*(i.e. Rhizosolenia)*
Pennate	Forma que tiene las dos mitades idénticas, como la reflejo en un espejo	*(i.e. Asterionellopsis)*
Segmentado	El cuerpo esta separado por secciones, como chorizo	*(i.e. Guinardia)*
Céntrico	Una forma que si se corta por la mitad, la parte de arriba y abajo serían idénticas	*(i.e. Coscinodiscus)*
Cloroplasto	El órgano del fitoplancton donde ocurre la fotosíntesis None available in original, maybe we can find one elsewhere.	
Núcleo	El órgano donde se encuentra el DNA y el cromosoma None available in original, maybe we can find one elsewhere.	
Cadena	La forma donde una serie de organismos idénticos están pegados	*(i.e. Odontella)*
Raphe	La línea que separa dos partes iguales	*(i.e. Pleurosigma)*
Trough	Un hoyo en el medio	*(i.e. Ceratium)*
Eyespot	Una sección de pigmento sensitiva a la luz	*(i.e. Pavlova)*
Step-chain	Segmentos que están pegados juntos para formar una serie de escalones	*(i.e. Pseudo-nitzschia)*
Plated	Armadura en forma de platos	*(i.e. Protoperidinium)*
Theca	Muchas capas de membranas, algunas tienen escamas	*(i.e. Prorocentrum)*
Flagela	Forma de látigo que se menea, sirve para moverse	*(i.e. Karenia)*
Peduncle	Una boca para envolver comida	*(i.e. Pfiesteria)*
Espinas	Estructuras sólidas que salen de la parte de arriba	*(i.e. Chaetoceros)*
Bilobulado	Divido en dos lóbulos o secciones	*(i.e. Akashiwo)*
Frustule	Forma redonda echa de silicato como una casita de vidrio	*(i.e. Coscinodiscus)*

2. **Dibuja** tu plancton con todas las características que escojas. Después usa los materiales para crear un plancton de tercera dimensión.

3. **Ponle nombre!** Todos los organismos tiene su propio nombre científico. El nombre debe incluir el genero (con mayúscula) y el nombre de la especie, y se escriben con letra cursiva. Puedes usar nombres de raíz Latín que significado que tengan algún significado relacionado con tu plancton (por ejemplo, bi= dos, bilobulado por que tiene dos lóbulos). Especies también pueden ser nombradas según la persona que lo descubrió, el lugar, su color, tamaño, forma, o sí se parece a otro especies.

Marine Mammal Adaptations

LESSON 6.4

Summary

A visit from Whales on Wheels (WOW) takes students into the world of whales; how they hear underwater, an introduction to the different whales along our coast, and includes an activity for students to map out the relative sizes of marine mammals. In "What's for Dinner?" the class calculates how much food they would have to eat in a day if they were a sea otter, and how many pizzas a blue whale would need to eat every day (using the equivalent weight of pizza to krill!).

Learning Objectives

Students will be able to:

- List the five features of a mammal using the "WHALE" acronym
- Name three marine mammals in the Sanctuary, and their relative sizes
- Name two adaptations marine mammals have to stay warm in the ocean
- Describe how sea otters eat one-quarter of their body weight each day, and why they need to eat so much

Background

Whales, seals, sea lions, sea otters, and humans are all mammals and share five basic mammalian characteristics. Mammals spending part or most of their lives in the ocean are called marine mammals. Marine mammals include the cetaceans (whales, dolphins, and porpoises), the pinnipeds (seals and sea lions), and sea otters. Diverse habitats and nutrient-rich Sanctuary waters attract 33 marine mammal species to California's coast. Some make Sanctuary waters their permanent home while others migrate through. Marine mammals forage for food in the ocean and some, like sperm whales and elephant seals, are able to dive to great depths to find a meal. Marine mammals have characteristics, or adaptations, that help them survive in the ocean. These adaptations include body parts or behaviors that help them to stay warm and to find food.

Staying Warm

Water conducts heat away from the body three times faster than air. That's why California SCUBA divers and surfers usually wear wetsuits; it's important for mammals entering the ocean to stay warm. Thermoregulation is the term used for the different ways animals keep their temperature stable. With the exception of sea otters, all marine mammals have a thick, insulating layer of blubber, or fat, to keep them warm. Like a wetsuit on humans, a layer of blubber helps marine mammals to maintain their body temperature (insulation). In addition to their blubber layer, seals and sea lions have a warm fur coat to keep them warm or insulated. Sea otters lack a blubber layer but have the densest fur coats of any animal on the planet, with up to a million hairs per square inch of their bodies.

Duration

Marine Mammals and Keeping Warm in the Cold: 10 minutes
Thermoregulation Rotations: 30 minutes
WOW Presentation: 60 minutes
What's for Dinner?: 20 minutes

Teacher Prep

1. Read activity background
2. Contact Whales On Wheels (see contact list) at least two to three weeks before to arrange classroom presentation.
3. Gather materials (ice must be a last minute purchase)
4. Set up thermoregulation stations
5. If possible, prepare in advance a blubber glove and an air glove

Making the blubber glove:

- Fill one-gallon zip-lock freezer bag half-way with Crisco or lard. You will be discarding this after using it, and to keep things from getting too messy, follow these directions closely!
- Turn a second one-gallon freezer bag inside out and place into the first bag containing lard.

(cont. on next page)

Marine Mammal Adaptations

- Interlock the two bags to each other using the "zipper" closure, if possible.
- Teacher Tip: Tape over zippered seam with duct tape.
  Put your hand into the second bag and press into the first, spreading the lard as evenly between the two bags as possible.
- Your insulated blubber glove is now ready.

Making the air glove:
- Tear newspaper into small scraps and loosely fill one one-gallon zip-lock freezer bag with the scraps.
- Turn second freezer bag inside out and place into the paper-filled bag.
  Put your hand into the second bag and press into the first, making sure the newspaper is evenly spread out.
- Interlock the two bags to each other using the "zipper" closure, if possible. Make sure there is a cushion of air in-between the two bags.
- Teacher Tip: Tape over zippered seam with duct tape.
- Your insulated air glove is now ready.

Marine mammals must eat a lot to have enough energy to stay warm in the cold ocean. Some animals have a fast metabolism, which is the chemical process that occurs within a living organism in order to sustain life. For example, sea otters eat about 25% of their body weight every day. Large meals and quick digestions fuel metabolism and produce body heat.

Marine mammals search for food in the ocean utilizing a diverse array of adaptations for finding food. Elephant seals dive to depths of 400-600 meters in search of prey. They have adaptations that allow them to stay under water for twenty minutes or more without taking a breath. Large eyes help them to utilize available light in deep, dark waters and may help them to locate bioluminescent prey like squid. Sea otters, in contrast, remain close to shore and to the surface while searching for food. They hunt primarily by sight and feed on a diverse group of invertebrates like abalone, sea urchins, and snails. Nimble paws and a food storage "pocket" in the armpit area help an otter in food collection.

Baleen whales, like humpbacks and blue whales, feed on plankton. An average-sized blue whale will eat 900-4100 kg (2,000-9,000 pounds) of plankton each day during the summer feeding season and must migrate to areas where plankton abounds. Behaviors, like body parts, are adaptations and thus migration is an adaptation for finding food.

Toothed whales, like orcas, dolphins and sperm whales have developed an elaborate system for locating food. Like bats, these whales produce and receive sound waves that enable them to locate a meal. These sonar-using cetaceans produce and receive sound energy using structures in their head region. The sound travels through the water, strikes an object, bounces off of the object, and the echo returns to the whale. In this manner, toothed whales are able to "see" what is out in front of them using sound to paint a picture. This sophisticated use of sound to locate objects is called echolocation.

Activity Procedure

Marine Mammals

1. Select the marine mammals from the species cards and have students pass them around as you write the word "Whale" on the blackboard.
   W = warm blood (all mammals have warm blood)
   H = hair or fur (all mammals have hair or fur; even whales, dolphins, and porpoises have hair at some point in their development)
   A = air (all mammals breathe air using lungs)
   L = live young (all mammals, with the exception of the platypus and kin, produce live young)
   E = eat milk (all mammals drink or "eat" milk when young)

Some marine mammals, like whales, in many ways, resemble fish. Whales and fish have fins and spend their entire lives in water. However, fish, in contrast to mammals, have cold blood (are ectotherms), lack hair or fur, breathe underwater using gills, and do not drink milk as youngsters. Remembering the five shared characteristics of mammals will help students to understand that whales are not a type of fish! Refer to lesson 2.3 for more information on characteristics of marine mammals.

Keeping Warm in the Cold

1. Explain to students: Marine mammals have characteristics or adaptations that help them survive in the ocean. Adaptations can include body parts or behaviors that help animals stay warm and find food. Ask students: How do you think marine mammals such as seals, sea lions, whales, dolphins, and sea otters stay warm in the cold ocean? Tell students: Today you will learn how marine mammals have adapted to resist the cold ocean water.

2. Divide the class into pairs that will rotate through the stations

Thermoregulation Rotation 1: Blubber glove

Teacher Tip: Prepare the blubber glove and air glove in advance.

1. Both stations require a five-gallon bucket half-filled with water and ice. Optional: Before putting their hands in the water, students may check the temperature of the water inside and outside the glove. Place a thermometer in the water and read the temperature. Put the thermometer in the blubber bag and place the bag in the water without allowing ice water into the bag. Students peer into the glove and read the temperature inside.

2. Each student gets a turn to be the scientist and the timekeeper. Each student will first predict: How long can they keep their uncovered hand in the water? How long can they keep their covered hand in the water? Remember, marine mammals are in the water most of the time—and whales and dolphins are in the water all of the time.

3. The scientist puts on the blubber glove, fitting a rubber band around the bag at the wrist to make sure the ice water does not enter the glove. The timekeeper gets ready to start the timer. When the scientist says "Start," she/he puts the blubber glove hand and their free hand into the ice water at the same time, and the timekeeper starts the time. When the scientist no longer can withstand the cold with their bare hand, she/he pulls the bare hand out of the water but keeps the blubber glove hand in the water. The timekeeper tells them their time, and keeps the timer going until the cold is too much for the blubber glove hand. Teacher Tip: In the interest of time, timekeepers should stop the experiment at three minutes.

Teacher Tip: This activity consists of three sections you can do independently of each other: Thermoregulation Activity (two stations), Whales on Wheels (WOW) Presentation, and What's for Dinner?

Materials

- Two timers
- Two thermometers
- Four zip-lock plastic freezer bags
- One large container of solid shortening or lard (such as Crisco)
- 3-4 sheets of newspaper
- Two five-gallon tubs
- One bag of ice cubes
- Water to fill tubs

Vocabulary

Adaptation
Calories
Echolocation
Insulation
Marine mammal
Metabolism
Plankton
Pinniped
Thermoregulation

Journal Prompt Closing Activity

Students fill in their journals with how long they could keep their bare hands in the cold water, with blubber insulation, and with air insulation.

Students write in their journals how much food they would need to eat if they were a sea otter, then answer these questions:
Why do sea otters need to eat so much food?
What would happen to sea otters if there were fewer abalone, sea urchins, fish, and other shellfish?
What would happen to whales if there were fewer krill?

4. Repeat until all students have had a chance to be the scientist and the timekeeper.

5. How long can the students keep their bare hand in the ice water? How about the blubber-gloved hand? Students record their times in their journals.

Thermoregulation activity, Rotation 2: Air glove

1. As in rotation 1, students may take the water temperature (optional) and then take turns wearing the air glove, placing both the gloved and bare hands into the ice water at the same time. Another student in the group will be the timekeeper.

2. Repeat until all students have had a chance to be the scientist and the timekeeper.

3. How long can the students keep their bare hand in the ice water? How about the air-gloved hand? Students record their times in their journals.

What's for Dinner?

1. Tell students: Another adaptation marine mammals have for staying warm in the ocean is that they eat lots and lots of calories. Calories, in the form of food, give them the energy to stay warm in the cold ocean. How much would you have to eat if you were an otter in the ocean?

2. Ask students: How much do you weigh? Write your weight in your journals. If students don't know for sure, have them estimate 80 pounds.

3. Use the chart below to help compare how much a student weighs and would have to eat per day, to keep up with how much a sea otter eats in a day. Otters eat a quarter of their body weight each day. An average weight for an adult sea otter is 60 pounds, so it needs to eat 15 pounds (60/4) every day to survive.

4. Write these questions on the board and fill in the table as students help you calculate these numbers (answers in parentheses). Remind students that sea otters and blue whales do not eat pizza, burritos, or hamburgers. And students, of course, eat a more balanced diet than pizza, burritos, or hamburgers. This is for food volume comparison only, food choices aside!

How much does it weigh?
How many pounds of food does it need per day?
How many pizzas, burritos, or hamburgers per day?
(Two slices of pizza, one burrito, or one hamburger each weigh one-quarter pound)

Sea otter: 60 pounds
(They eat a mixture of abalone, sea urchins, fish, and other shellfish)
One-fourth of its body weight 60/4= 15 pounds per day
Pizza (one pizza = one pound) 15 pizzas
Burritos: 15 x 4 = 60 burritos
Hamburgers: 15 x 4 = 60 hamburgers

Student: 80 pounds
If you were an otter, 80/4 = 20 pounds per day
20 x 1 = 20 pizzas
20 x 4 = 80 burritos
20 x 4 = 80 hamburgers

Blue whale: 160 tons (of tiny shrimp called krill)
4 tons (8000 lbs) per day
8000 x 1 = 8000 pizzas
8000 x 4 = 32000 burritos
8000 x 4 = 32000 hamburgers

Whales on Wheels (WOW) Presentation

1. Whale hearing and sonar: Students will lie down, close their eyes, and pretend they are under water. The WOW presenter will play three different whale sounds for them and ask if they think the whales that made the sound are large or small. Why is hearing so important for whales?

2. Specimens' station: Students will explore different species artifacts and learn about their uses.

3. WOW rope: Students will compare the length of an otter to that of a blue whale using a 100 foot rope labeled with the length of various marine mammals and information on each species. Students will learn: What do otters eat? What do whales eat? Pound for pound, which animal do they think eats more food? Why?

Adapted from What's For Dinner? Sea Searchers Handbook, Monterey Bay Aquarium

Activity Extensions

Nothing beats seeing marine mammals with your very own eyes, and luckily there are viewing opportunities throughout the Sanctuary. You can visit Elkhorn Slough and see sea otters and seals, offshore rocks where seals and sea lions haul out, or best of all, Año Nuevo State Park for a guided tour of the magnificent elephant seals. An adult male is as big as a car! The peak season is from January to March, when you can witness incredible mating displays and might spot a pup being born.

Marine Debris, Litter and You

LESSON 6.5

Summary

Students learn about various types of litter and marine debris. They conduct a cleanup for their schoolyard or other public area discussing each item and how it should have properly been disposed. Students brainstorm slogans and make posters about reducing litter and marine pollution.

Learning Objectives

Students will be able to:

- Know the meanings of vocabulary terms, including litter and marine debris
- Understand some of the consequences of marine debris on the marine environment
- Participate in a local cleanup to remove litter from the environment so it does not become marine debris
- Make posters to educate others about litter and how to prevent it

Background

Litter is a term for pieces of trash that have been carelessly scattered in a public place or the outdoors. Debris is sometimes used as another word for litter. In general, the term litter is used for trash discarded on the ground, and marine debris is the term for trash discarded in the ocean. Litter, trash and marine debris are all forms of pollution, which causes harm to the natural environment.

Litter, trash and marine debris have become a big problem on beaches and in the ocean worldwide. Some of the most common items include cigarette butts, plastic bags and wrappers, caps and lids, plastic bottles, glass bottles, plastic straws, beverage cans, bottle caps, cups and eating utensils. Heavy items, like metals and glass, sink and fall to the seafloor. Lightweight items, like plastic and paper, float on the surface and are carried along ocean currents.

Marine debris comes from many different places. Beachgoers may leave behind food packaging, beverage containers, cigarette butts, or toys like shovels, pails, and Frisbees. When carelessly disposed of, litter and trash on land can be blown into rivers or streams, then carried to sea. Rain water runoff flowing down messy streets can carry litter into storm drains, eventually dumping it into the ocean. Careless boaters throw trash overboard, or let it fall into the water. Fishing gear, including nets, lines, and other equipment can be lost at sea and end up as marine debris.

Duration

Trash Discussion:
20 minutes
School Yard Cleanup:
30 - 40 minutes
Slogan Posters:
20-30 minutes

Teacher Prep

1. Read activity background
2. Check with principal on places to put posters and do a schoolyard cleanup
3. Photocopy Trash Timelines, one per 2-3 students (optional)
4. Collect Materials for activities:
   - Litter Items: see list
   - School Yard Walkabout:
     Trash Bags
     Gloves
   - Art Supplies for posters

Marine Debris, Litter and You

LESSON 6.5

Materials

- Trash Bags
- Gloves for students
- Art supplies for posters: Pencils, paint and paintbrushes, colored pencils, crayons, etc
- Trash Timeline Worksheets
- Banana peel
- Paper bag
- Cotton rag
- Cigarette butt
- Plastic bag
- Fishing nets
- Leather boot
- Rubber sole (of a boot)
- Tin can (soup or vegetable can)
- Aluminum can (soda can)
- Plastic 6-pack rings
- Plastic bottles
- Disposable diapers
- Fishing line

Teacher Tip: If you cannot collect all items, find a picture of the items or write the list on the board or chart paper.

Marine debris can harm or even kill marine wildlife. Animals may strangle and drown from getting tangled in plastic and metal strapping. Small invertebrates, like crabs can crawl into glass bottles. As they grow, they become too large to leave and are trapped. Birds, fish, and mammals often mistake trash for food. Some birds feed small plastic pellets to their young, thinking it is food. Sea turtles can mistake plastic bags and balloons for jellies, one of their favorite foods. Even whales have been found dead with plastic bags inside their stomachs. Plastic and other types of debris may block air passages and prevent animals from breathing, causing suffocation.

Careful collection, handling, and disposal of trash, as well as reducing the amount of trash produced, can help solve the marine debris problem. Many discarded items can be reused or recycled by placing them in a recycling bin. Other kinds of trash should be disposed of properly in trash containers, where they are taken to a solid waste landfill. An even better option is to produce less waste in the first place. Say no to bags you don't need, reuse bags and other items, and shop for items that have less packaging.

At a time when environmental problems seem beyond individual action, reducing trash and marine debris is something people of all ages can do, just by disposing of trash properly, and reducing, reusing and recycling.

Activity Procedure

1. Place the trash items listed in the Materials Section on a table in the middle or front of the class. Ask students to explain where these discarded items should be placed (in the trash can or recycling bin). If they were properly disposed of, where would they go? (See Lesson 3.8 Where Does Our Garbage Go?)

2. Explain to the students that some people don't discard of trash properly. Introduce and define the words litter, marine debris and pollution. The items in the classroom are common litter items — they are frequently thrown away improperly and end up in the ocean. Ask students: When people litter, what happens to the items that have been left outside? Refer to their knowledge of watersheds and storm drains. Where do watersheds eventually end up? What happens to trash on the street that gets washed into storm drains?

3. Ask students to raise their hands if they think these items will decompose or just "go away." Why or why not? Refer to the Trash Timeline Answers for a list of estimated time it takes for items to decompose. Explain to students that even "decomposable" materials like cotton and banana peel take a long time to decompose, while other items take a very long time. In the meantime, they can hurt wildlife on land and in the ocean. Explain that the Monterey Bay National Marine Sanctuary conducts clean-ups on beaches and creeks to help prevent litter from becoming marine debris.

Marine Debris, Litter and You

4. Distribute gloves and bags to the students. Designate some bags as "Recycling" and some as "Trash." If your school has a composting bin, add a bag for "Compost." Take a walk on the schoolyard and collect litter. As a class, look at each item of litter and discuss how it should properly be disposed of. Can it be recycled? Put it in the recycling bag. Is it litter? It could end up in the ocean! Get it into that trash bag and out of the environment! Could it decompose? Put it in the composting bin! Finish the tour of the schoolyard at the garbage dumpster and recycling bin. Have students remove their gloves and place them in the garbage bags. Dispose of the bags in their appropriate places. Congratulate the class for a job well done! They did their part to clean up litter and prevent it from becoming marine debris! Good work!

5. When you return to the classroom, tell the class that they will be making posters encouraging people not to litter, because it will lead to marine debris. If your students are bilingual, encourage them to write their slogans in their native language, or in both English and their native language.

6. Brainstorm a list of possible slogans. Your list might look like this:
   - Be part of the solution to marine debris pollution!
   - Dispose of trash properly—don't be a litter bug!
   - Don't release balloons - they can end up in the ocean and be mistaken for food
   - Buy recycled—look for products made in recycled packaging.
   - Trash on the street ends up in storm drains, so don't litter!
   - Don't pour motor oil or other toxic liquids on the street or down a storm drain.
   - Discard fishing line, bait packages and other gear in a trashcan.

Vocabulary

Decompose
Landfill
Litter
Marine debris
Pollution
Recycle
Reduce
Reuse
Runoff
Storm Drain
Trash

Journal Prompt Closing Activity

Walk around the school and have students put their message posters around the schoolyard, auditorium, and office. Tell students that you are proud of them for doing their part to reduce litter and pollution. Encourage them to find other places to place their poster, including their home, church, or parent's workplace.

- Be sure trash stays in the bag—securely close the top and dispose of in a trash container
- Place 6-pack ring holders in the trash so they don't trap animals on land or in the ocean.
- Reduce the amount you throw away—don't be wasteful, reuse what you can, and recycle.
- Keep cigarette butts off beaches and streets.
- Purchase items in bulk instead of smaller sizes (there is less packaging).
- Reuse items like bags and containers instead of throwing them away.
- Reuse boxes, envelopes, newspapers and other packing materials.
- Reuse paper or stationery for scratch paper.
- Recycle as many items as possible like cans, bottles, newspapers, cardboard, batteries, etc.
- Participate in local beach, river, or stream clean ups.
- Make more trash items degradable so they don't last as long

7. Distribute art supplies—paper, pens, crayons, paint, etc. Have the class work on their posters. When they are finished, have each student show their work. Be sure to applaud after every poster!

Trash Timeline

Breaking Down Trash Timeline

Trash Items Your Own "Best Guess"

Decomposition Times Your Own "Best Guess"

Decomposition Order (Shortest to Longest, 1-16)

Decomposition Times as Estimated by "Garbologists"

Decomposition Order (Shortest to Longest, 1-16) Estimated by "Garbologists"

Cotton rag
Tin can (soup or vegetable can)
Banana peel
Plastic bag
Disposable diaper
Plastic 6-pack rings
Cigarette butt
Fishing nets
Glass bottle
Rubber sole (of a boot)
Fishing line
Styrofoam
Plastic bottles
Aluminum can (soda can)
Leather boot
Paper bag

Trash Timeline
Cronología para la Descomposición de Basura

LESSON 6.5

Tipo de Basura ¿Cuanto crees que tarde en Descomponerse?

¿Cual crees que se Descomponga primero y cual al ultimo? (Numéralos del 1-16)

Tiempo que tarda en Descomponerse según el Basurologo

Orden de Descomposición según el Basurologo (Numéralos del 1-16)

Trapo de algodón
Lata de metal (de sopa o vegetales)
Cáscara de plátano
Bolsa plástica
Pañal desechable
Contenedor de 6-pack
Colilla de cigarro
Red para pescar
Botella de vidrio
Suela de hule de bota
Cuerda para pescar
Unicel
Botella plástica
Lata de aluminio de soda
Bota de cuero
Bolsa de papel

Trash Timeline Answers

Banana peel—3 to 5 weeks
Paper bag—1 month
Cotton rag—5 months
Cigarette butt—2 to 5 years
Plastic bag—10 to 20 years
Fishing nets—30 to 40 years
Leather boot—40 to 50 years
Rubber sole (of a boot)—50 to 80 years
Tin can (soup or vegetable can)—80 to 100 years
Aluminum can (soda can)—200 to 500 years
Plastic 6-pack rings—450 years
Plastic bottles—450 years
Disposable diapers—500 years
Fishing line—600 years
Styrofoam—unknown
Glass bottle—unknown

Species Most Affected by Marine Debris
Yellowfin tuna
Blue whale
Brown pelican
Gray whale
Humpback whale
Leatherback sea turtle
Northern elephant seal
Ocean sunfish
Orca
Sooty shearwater
Southern sea otter
Western gull
Harbor seal
Snowy plover
Marbled godwit

Oil Spill Cleanup

LESSON 6.6

Summary

In these activities, students simulate an ocean oil spill and experiment with ways to clean it up. They evaluate how oil affects bird feathers and animal fur. Students brainstorm ways in which we can reduce oil consumption, and decide upon three actions that they can take that will make a difference in how much oil they use.

Learning Objectives

Students will be able to:

• Describe three ways in which we use oil
• Describe ways that marine birds and mammals are harmed by oil spills
• Describe ways that oil spills are cleaned up

Background

Humans worldwide use nearly 3 billion gallons of oil each day. In the United States, we use about 700 million gallons of oil each day, which is 23 percent of the worldwide consumption. Oil enters the marine environment in many ways.

Oil is a nonrenewable resource. Crude oil is a basic raw mineral pumped from the earth. It is one of the most valuable natural resources on earth, because we depend upon it in so many ways, including to fuel cars, trucks, and buses, to heat houses, lubricate machinery, make the asphalt used to pave roads, to make plastics, and in medicines, ink, fertilizers, pesticides and paints.

Unfortunately, oil sometimes ends up in the ocean. Oil spills into rivers, bays, and the ocean are usually caused while the oil is being transported. Accidents involving tankers, barges, pipelines, refineries, and storage facilities can cause widespread damage to the marine ecoysystem. Oil floats on salt water in the ocean and usually floats on fresh water in rivers and lakes. Oil usually spreads out rapidly across the water surface to form a thin layer called an oil slick.

Depending on the circumstances, oil spills can be harmful to marine birds and mammals, and also can harm fish and shellfish. Oil destroys the insulating ability of fur-bearing mammals, such as sea otters, and the water-repelling abilities of a bird's feathers, thus exposing these creatures to the harsh elements. Many birds and animals also ingest (swallow) oil when they try to clean themselves, which can poison them. Depending on just where and when a spill happens, from just a few to up to hundreds or thousands of birds and mammals can be killed or injured.

Duration

What Are Oil Spills? What Causes Them? 10-20 minutes

How to Clean Your Own Oil Spill: 40-60 minutes (including clean up)

Teacher Prep

1. Read activity background, review activity
2. Assemble materials
3. Photocopy Oil Spill Cleanup worksheet, one per group

Oil Spill Cleanup

LESSON 6.6

Materials

One for each group of four or five students:

- Oil Spill Cleanup Worksheet
- One dish tub half full of water
- Small rectangle of aluminum foil (5” x 7”)
- Pair of rubber gloves
- Eye dropper
- Pipette
- Hand lens
- Drinking straw
- Feather and fake fur (from watershed science kit)

For groups to share:

- Cooking oil
- Cotton balls or ripped pieces of paper towel
- Lots of newspaper
- Dishwashing liquid
- Pieces of rope
- Plastic trash bags

Vocabulary

Crude oil
Dispersant
Oil spill
Sorbent
Toxic

Once oil has spilled, any of various local, state, and Federal government agencies, as well as volunteer organizations, may respond to the incident, depending on who’s needed. People may use any of the following kinds of tools to clean up spilled oil:

- booms, which are floating barriers to oil (for example, a big boom may be placed around a tanker that is leaking oil, to collect the oil)
- skimmers, which are boats that skim spilled oil from the water surface
- sorbents, which are big sponges used to absorb oil
- dispersants and biological agents, which break down the oil into its chemical constituents
- in-situ burning, which is a method of burning freshly-spilled oil, usually while it’s floating on the water
- washing oil off beaches with either high-pressure or low-pressure hoses
- vacuum trucks, which can vacuum spilled oil off of beaches or the water surface
- shovels and road equipment, which are sometimes used to pick up oil or move oiled beach sand and gravel down to where it can be cleaned by being tumbled around in the waves

The methods and tools people choose depends on the circumstances of each event: the weather, the type and amount of oil spilled, how far away from shore the oil has spilled, whether or not people live in the area, what kinds of bird and animal habitats are in the area, and other factors. People also may set up stations where they can clean and rehabilitate wildlife.

In the United States, depending on where the spill occurs, either the US Coast Guard or the US Environmental Protection Agency takes charge of the spill response. They, in turn, often call on other agencies (NOAA and the Fish and Wildlife Service are often called) for help and information.

The goal of new Federal regulations is to prevent oil spills from happening. People who cause oil spills now must pay severe penalties, and the regulations also call for safer vessel design in the hopes of avoiding future spills. In the U.S., people who respond to oil spills must practice by conducting training drills, and people who manage vessels and facilities that store or transport oil must develop plans explaining how they would respond to a spill, so that they can respond effectively to a spill if they need to.

Oil Spill Cleanup

LESSON 6.6

Because oil and oil products in the environment are toxic and can cause harm, we need to prevent problems when we can. For example, by avoiding dumping oil or oily waste into the sewer or garbage, we avoid polluting the environment we live in. Sometimes, we can find ways to avoid using oil in the first place: for example, we can bicycle, walk, or take the bus rather than taking a car to some places we need to go. When we use less oil, less needs to be transported, and there's a lower risk of future oil spills. We all share both the responsibility for creating the problem of oil spills and the responsibility for finding ways to solve the problem.
(Source: http://www.response.restoration.noaa.gov/kids/spills.html)

Activity Procedure

1. Start a discussion with your class about oil spills. How do you think oil spills happen? How does oil get into our environment? List their ideas on the board. Your list might look like this:
   - Accidents while transporting it
   - People making mistakes or being careless
   - Equipment breaking down
   - Natural disasters such as hurricanes
   - Illegal dumpers

2. Tell students: Oil spills cause harm to marine birds, mammals, fish, and shellfish by direct contact and through long-term exposure, oil can destroy the insulating ability of fur-bearing mammals, such as sea otters, and the water-repelling abilities of a bird's feathers. Birds and animals swallow toxic oil when they clean themselves.

3. Ask students: How many of you have tried to clean up oil at your house—either in the kitchen or the garage? Tell students: Cleaning up oil is messy and hard as you try, there is always some left over. Oil spill cleanup experts have different ways of cleaning up oil in the water and when it gets to shore:
   - Boats with special "skimmers" can remove oil, much like a ladle or large spoon in a soup pot
   - Chemicals called dispersants, which are like detergents, break oil into droplets, which bacteria and other natural organisms in the water can then digest
   - Burning is a quick way to be sure a spill doesn't get to shore (but causes air pollution)
   - Absorbent pillows, like cotton balls
   - Big floating booms, giant Styrofoam logs wrapped in plastic can contain an oil spill

4. If the spill does get to shore, sorbents are used to soak it up. Sorbents are made of polyethylene, a plastic made out of oil.

Journal Prompt Closing Activity

An ounce of prevention is worth a pound of cure. When we use less oil, less needs to be transported. In their groups, students brainstorm ways that they can help prevent oil from entering the environment. Then, they write a list of ways that they and their families can reduce their use of things made with oil. In their journals, students choose three actions they will take that make a difference in oil use.

5. Ask students: What do you think are the problems with cleaning up oil spills? Right after the oil is spilled, it lands on birds and mammals in the area. Once the oil is cleaned up, disposal of the oil remains a problem. It's impossible to get all the oil, especially if wind and high waves occur. When oil hits shore, it can seep into rock crevices and be difficult to remove.

Clean Up An Oil Spill

1. Divide students into groups of four or five. Groups will cover their working area with lots of newspaper. Each group gets one dish tub. Teacher Tip: You may also do this activity as a teacher demonstration.

2. Groups fill their dish tubs half-way with water and place tubs on newspaper.
   Each groups gets:
   Oil Spill Cleanup Data Sheet and Worksheet
   Small rectangle of aluminum foil (5"x7")
   Pair of rubber gloves
   Eye dropper
   Pipette
   Big spoon or soup ladle
   Hand lens
   Straw
   Feather
   Piece of fur

3. Groups place a feather and a piece of fur in their tubs.

4. Groups shape the aluminum foil into a boat, carefully fill it with cooking oil and float it in their tubs.

5. When all groups are ready, tell them to choose one student to put on the rubber gloves and tip over their vegetable oil tanker. Tell students: Watch what's happening to the oil. Is it mixing with the water? Is it sinking, floating or spreading?

6. After five minutes, tell students to take the feather and the fur out and set it aside while they clean the "oil spill." Tell students: Try to contain the oil spill with a loop of string/rope. Tell students: Use the different materials to clean up the oil (paper towel, cotton, soap, and straw) and describe your results on the data sheet. This gets messy, so be sure students keep their messes on the newspaper and wash their hands when they are done.

7. After the spill cleanup, students clean up the feather and fur with the same materials and describe the effectiveness of each cleanup method on the chart, then answer the worksheet questions. Teacher Tip: Each group can answer the worksheet questions, or you can do it together as a whole class. If doing it as a group, each group chooses one student to be the recorder.

8. Ask students: What are some ways we can reduce the amount of oil we use? After students brainstorm some ideas, add other ideas listed below.
   - Bicycle, walk, carpool, or take the bus rather than taking a car
   - Reduce, recycle, and reuse packaging, plastic bags, and plastic container
   - Drive fuel efficient cars and drive the speed limit
   - Use metal utensils, a glass, or a plate instead of paper or plastic cups and plates and utensils
   - Bring a canvas bag to the store instead of accepting paper or plastic, and reuse bags from the store
   - Share items with friends and family and use the library
   - Buy products with less packaging—one-third of our garbage is packaging
   - Bring lunch in reusable containers
   - 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.
   - If you don't really need something, don't buy it!

How Does Oil Affect Feathers? (optional)

1. Groups examine a clean dry feather with a hand lens, and students sketch what they see.

2. Groups dip the feather in clean (un-oiled) water for one or two minutes and examine again. Students sketch it and compare it to the first observations.

3. Place the feather in the dish tub with oil for one or two minutes, then examine, sketch, and compare to the previous sketches. Make sure the feather gets coated with oil.

4. Clean the feather in detergent, rinse in water, and dry it. Examine with a hand lens, sketch, and compare to the previous sketches.

5. Students discuss in their groups the changes in the feather after exposure to oil and then to detergents. How would the changes they see affect normal bird activity?

Adapted from "An Oily Mess" Sea Searchers Handbook, Monterey Bay Aquarium, p. 136.

Oil Spill Cleanup Data Sheet

Hoja de Datos: Limpieza del Derrame de Petróleo (o aceite)

Team Members/*Miembros del grupo:*____

Cleaning Method *Método de Limpieza*	Results and observations *Resultados y observaciones*

Notes/*Notas:*

Oil Spill Cleanup Worksheet

Hoja de Trabajo: Limpieza del Derrame de Petróleo

Write 3 things that are made from oil.
Escribe tres productos que están hechos con petróleo.

Is it possible to remove all of the oil from the ocean? Why?
¿Es posible remover todo el petróleo del mar? ¿Por qué?

Is it possible to remove all of the oil from the feather and fur? Why?
¿Es posible remover todo el aceite de las plumas y de la piel de los animales? ¿Por qué?

Which method seemed the most effective at removing the oil from the water? Why?
¿Cuál método fue el más efectivo para remover el aceite del agua? ¿Por qué?

Which method seemed the most effective at removing the oil from the feather and fur? Why?
¿Cuál método fue el más efectivo para remover el aceite de la pluma y del pedazo de piel? ¿Por qué?

How do you think these cleanup methods would work in the open ocean?
¿Cómo crees que estos métodos trabajarían en el mar abierto?

While you contain the oil with your string in your mini-ocean, what happens if a wave comes?
¿Mientras detenías el aceite con el cordón, que hubiera pasado sí hubiera llegado una hola?

How would ocean currents, winds, and tides affect an oil spill cleanup operation?
¿Cómo crees que las corrientes del mar, el viento y la marea afectarían la limpieza de un derrame de petróleo?

Appendix A

Dear Parents,

Your child has been selected to participate in the MERITO Watershed Academy after school program. The Monterey Bay National Marine Sanctuary and ______________________________ (school name) have come together to create a very exciting science after school program. The Watershed Academy is designed to provide students with the opportunity to experience meaningful hands-on field trips and in-class watershed and ocean science activities while meeting local scientist and experts.

The Watershed Academy after school program will take place at __________________ (school name). Students will meet once a week on ____________ (day) from _______________ (time), starting on_______________________(date). The program will be held in ____________ (room#) with _____________________________ (teacher's name). During this time, your child will participate in hands-on science activities, experiments, games and learn more about science. There will be some walking field trips to near by natural areas and some driving field trips to farther local natural areas. Parents are always welcome to join us during field trips and in-class activities!

During the after-school activities and field trips, CSUMB interns and MERITO staff will occasionally assist the Watershed Academy teacher to act as mentors and expose your child to university role models to help raise aspirations and explore future career opportunities.

If you decide to have your child join the Watershed Academy after school program, we would like to request that you make every effort to have you child attend the activities and field trips just as if it were regular school. If for any reason your child cannot make it to the program on a particular day, please let us know to make a note on our attendance sheet. We are looking at attendance, and we want kids to enjoy and participate in all of our activities!

We are excited to have your child participate in the Watershed Academy program. For any questions or more information, please call ________________________________ (contact person and phone). We will be sending home permission slips for our field trips. Please fill them out completely, sign and return them to _______________________ in _______________(room #).

Best regards,
Watershed Academy after school program

____
Teacher's signature

Monterey Bay National Marine Sanctuary
Multicultural Education for Resource Issues Threatening Oceans
299 Foam Street
Monterey, California 93940

Estimados padres de familia,

¡Felicitaciones! Su hijo/hija ha sido seleccionado para participar en el programa MERITO después de clases llamado Academia Cuenca. El Santuario Nacional Marino de la BahÌa de Monterey y la escuela ________________ (school name) se han unido para crear un excitante programa después de clases. El programa ha sido diseñado para ofrecer a actividades y experiencias de ciencias significativas después de clases y paseos de exploración basados en investigaciones cientÌficas de la cuenca y del océano. Durante el programa, los estudiantes también tendrán la oportunidad de conocer y trabajar con expertos y científicos del área .

La Academia Cuenca se llevará acabo en la escuela ______________ (school name), en el salón ______ (room #) una vez por semana todos los ______________ (day) de __________________ (time) empezando el día ______________________ (starting date) con la maestra _________________ (teacher's name). Durante este tiempo los estudiantes participarán en actividades y juegos de exploración científicas en donde podrá aprender más acerca de las ciencias naturales. También habrán varios paseos en sesiones después de clases en donde a veces caminarán a lugares naturales cercanos y otras veces manejarán a otros lugares naturales de estas áreas. Los padres de familia están siempre invitados a venir a participar durante las actividades después de clases y en los paseos.

Durante algunas de las actividades y paseos tendremos estudiantes mentores de la universidad de la Bahía de Monterey(CSUMB) y a el personal de MERITO para ayudar a aumentar los conocimientos y aspiraciones académicas y explorar oportunidades de las profesiones universitarias futuras.

Sí usted decide permitir a su hijo/hija participar en el programa de la Academia Cuenca, le pedimos que usted haga cada esfuerzo necesario para que su hijo/hija asista a las actividades y paseos que ofrecemos, simplemente como si fuera la escuela regular. Sí tiene alguna pregunta o quiere más información, favor de llamarnos al _____________ (contact person and phone). Estaremos mandando formas de permisos para los paseos, por favor llene las completamente, firme y regrese las a la maestra_______________ (teacher) en _________ (room #).

Sinceramente,

La Academia Cuenca

____

Firma de la maestra

Monterey Bay National Marine Sanctuary
Multicultural Education for Resource Issues Threatening Oceans
299 Foam Street
Monterey, California 93940

Appendix C

Name/Nombre: ________________
Date/Fecha: ________________
School/Escuela: ________________

Draw a Scientist / Dibuja un Científico

What does this scientist do? / ¿Que hace este científico?
____
____
____
____
____

Appendix D

Scientific Method

1) Observation – Look:
Ex: study something around you.

2) Hypothesis – Guess:
Ex: bees like yellow flowers more then purple flowers.

3) Prediction – Explain:
Ex: I predict that more bees will visit yellow flowers than purple flowers.

4) Experiment – Test:
Ex: Record the number of times bees stop at yellow flowers and the number of times bees stop at purple flowers in a 2 minute period. Repeat 4 times.

5) Explain/Theory– Tell:
Ex: In my experiment I found that 48 bees visited yellow flowers during four 2 minute test periods. I found that 32 bees visited purple flowers during four 2 minute test period. Therefore my hypothesis of bees preferring yellow flowers over purple flowers is correct.

Método Científico

1) Observación – Mira:
Ejemplo: estudia algo a tu alrededor.

2) Hipótesis – Adivina:
Ejemplo: las abejas prefieren flores amarillas y no las moradas.

3) Predicción – Explica:
Ejemplo: Yo pienso que más abejas van a visitar a las flores amarillas que a las flores moradas.

4) Experimentar – Comprueba:
Ejemplo: Observar por dos minutos y anotar el numero de veces que las abejas visitan a las flores amarillas y a las moradas. Repetir el experimento 4 veces.

5) Explica/Teoría – Decir:
Ejemplo: En mi experimento encontré que 48 abejas visitaron las flores amarillas durante los 2 minutos y las 4 veces que lo hice y solo 32 abejas visitaron las flores moradas durante los 2 mismos minutos. Por lo tanto mi hipótesis es correcta por que mas abejas prefieren a las flores amarillas que a las moradas.

Appendix E

Key to Common Latin Roots, Prefixes, and Suffixes

Numbers
hemi, semi - half
penta - five
mono, uni - one
hexa - six
di, bi - two
octo - eight
tri - three
deca - ten
tetra, quadri – four

Descriptions and Markings
cypri, pulcher - beautiful
fasciatus - banded
ichthys - fish
lineatus - lined
marmoratus - marbled
notatus - marked
ocellatus - with an eye-spot
stigmata, maculatus - spotted
variatus - mottled
variegatus - variable
vittatus, taeniatus – striped

Color
albi, leuco - white
argent, argyro - silver
aur, aurat, chryso - gold
cerule, cyano - blue
flamme, pyrrho - flame
flav, xantho, galb, lute, thapsino - yellow
fuse, brunne - brown
nigri, melan - black
rose, rhodo - rose
rubi, rubr, erythro - red
viridi, chloro – green

Size, Shape, Body Description
acanth - spine
brevi, brachy - short
caudo, uro - tail
cephalo - head
corpor, soma - body
derma - skin
dorsi, noto - back
gaster - stomach
-issima, -tatos - "the most"
labio, chilo - lip
lepis - scale
longi - long
macro - large
mega - great
micro - small
multi, poly - many
nano – dwarf, very small
odont - tooth
ophthalmop - eye
oto - ear
pauci, oligo - few
pector - breast
phyllum - leaf-like
pinni, pinniss, ptero - fins
plani, platy - flat
pulcher, call, bell - beautiful
rostrum, rhino – nose
sterni - chest
stoma - mouth
ventro – belly

Appendix F

Latin, Greek, and English Roots of Areas of Scientific Study

Use this sheet to help find the scientist on "Scientist Bingo."

Suffix
"ologist" = "one who studies"

Prefix:
bio = living organism
botan = of plants
eco = house (Greek), more common use is environment
ento = insect
environ = around
geo = the earth
GIS = Global Information Systems
herpe = creeping things, common use is reptiles
hydro = water
ichthy = fish
meteor = celestial phenomena
micro = small, bio = living organism
orni = bird
ROV = Remotely Operated Vehicle
taxis = arrangement

Appendix G

Classification of Species in the Ocean

The major types of marine organisms come in many groups, especially animals. In fact, the marine environment has more animal diversity, as far as the major groups are concerned, than almost any other habitat. There are species from almost every major taxa. Below is a short list of the most common marine critters (found in almost all the oceans) and their common names.

Kingdom Protoctista
Phylum Chlorophyta (green algae)
Phylum Rhodophyta (red algae)
Phylum Phaeophyta (brown algae)
Phylum Bacillariophyta (diatoms)
Phylum Dinomastigota (dinoflagellates)

Kingdom Plantae
Phylum Anthophyta (seagrasses)

Kingdom Animalia
Phylum Porifera (sponges)
Phylum Cnidaria (hydroids, jellyfish, sea anemones, corals)
Phylum Platyhelminthes (flatworms)
Phylum Annelida (segmented worms)
Phylum Mollusca (chitons, snails, slugs, bivalves, octopods, squids)
Phylum Arthropoda, or Crustacea (crabs, lobsters, shrimp, barnacles)
Phylum Echinodermata (sea stars, brittle stars, sea urchins, sand dollars, sea cucumbers)
Phylum Urochordata (sea squirts, salps, larvaceans)
Phylum Chordata, or Craniata (sharks, rays, fish, reptiles, birds, mammals)

Appendix H

Nature Manners

- Stay on existing trails.
- Don't take short-cuts. Do not create new trails.
- Avoid using muddy trails, it will accelerates trial erosion.
- Do not block the trail.
- Do not litter. If you pack it in, pack it out.
- Obey gate closures and signs.
- Keep right, except when passing.
- Do not disturb the wildlife.
- Do not break off tree limbs or damage plants.
- Take only pictures; leave only tracks.

Modales en la Naturalezana

- Camina solo por los senderos correspondientes.
- No hagas senderos nuevos, ni tomes atajos.
- Trata de no caminar por el lodo porque acelera la erosión de los senderos.
- No bloquees el paso de los senderos.
- No dejes basura. Empaca todo lo que trajiste.
- Obedece todas las señales en los senderos y en las entradas.
- Camina por la derecha del sendero, excepto cuando pases a otros.
- No molestes, ni maltrates a los animales.
- No cortes ramas, ni maltrates a las plantas.
- Toma sólo fotos, deja sólo huellas.

Appendix I

Wildlife Viewing Etiquette

- Learn before you go. To get the most from your marine mammal viewing experience, read about local viewing areas and regulations before you go.
- Keep a distance. Use binoculars, spotting scopes, and cameras with zoom lenses to get a closer look.
- Hands Off. Never touch, handle, or ride marine mammals. Doing so may be illegal, and it may put you or the animal at risk.
- Do not feed or attract marine mammals. Junk food is not digested well by wild animals, and can cause illness or death.
- Never chase or harass marine mammals. It is dangerous to follow a wild animal when it is trying to escape.
- Stay away from marine mammals that appear sick or abandoned. Some marine animals, such as seals, leave the water at low tide as part of their natural cycle. There may be nothing wrong with an animal that is lying quietly on the beach. If you do encounter a marine animal that appears to be sick or injured, report it to the Marine Mammal Center at 415-289-7325.
- Marine mammals and pets don't mix. Wild animals can injure and spread diseases to pets. Many wild animals recognize dogs as predators and quickly flee when they see or smell dogs. Keep dogs on a leash and away from areas frequented by marine mammals.
- Lend a hand with trash removal. Human garbage is one of the greatest threats to marine mammals. Carry a trash bag with you and pick up litter along the shore.
- Help others become responsible marine mammal watchers and tour operators. Speak up if you notice other viewers or operators behaving in a way that disturbs marine mammals. Report violations of the law to the proper authorities.

Appendix J

Ocean Safety

Plan well. Tides of 0.0 or lower are best for viewing tidepool life. Check your local tide book to select the best day and time for tidepooling.

Dress for weather. Weather along the coast can be highly variable.
Dressing in layers is a good idea.

Dress for safety. Rocks and algae can be slippery. Wear shoes with good traction.

Watch the waves and keep an eye on the ocean. Before you go down to a tidepool, watch the waves to see where waves are crashing. Once at the tidepool area, always keep an eye on the ocean; rogue waves can be unpredictable and deadly.

Carry a first aid kit. Even the most safety conscious can get scrapes and scratches during a tidepool visit.

Have a Buddy. Make sure someone knows where you are.

Appendix K

Cleaning Our Environment

Summary
A beach, river, or neighborhood cleanup can be done as part of any appropriate field experience as a closing activity or as another component to your field trip. During this activity students have the opportunity to provide a service to the environment while learning about recycling, reusing, and reducing waste. Students learn that what we do on land can affect our rivers and ocean.

Learning Objectives
Students will be able to:
- Identify common items that contaminate beaches, rivers and neighborhoods
- Calculate percentages of most common trash items found in their clean up activity
- Learn ways to reduce pollution in beaches, rivers or neighborhoods

Materials
Trash Inventory sheets (attached)
Disposable rubber gloves and garbage bags (provided by MERITO staff)

Activity Procedure
Safety precautions
- Always have adequate adult supervision.
- Keep a first-aid kit and emergency phone numbers nearby.
- Let participants know not to pick up any broken glass or sharp objects.
- Make sure every participant wears at least one glove.

Fragile habitats
- Respect all habitats, particularly those with “Do Not Enter Signs.”
- Let participants know they should not get close to any animals or birds.
- Leave animals where you find them.
- Try to step on bare space free of animals such as snowy plovers.

Trash survey

1. Add all the pieces of trash to get a total quantity OR weigh all the trash together to get a total weight.
2. Figure what percent of the total each group represents by dividing the weight (or quantity) of a group by the total weight (or quantity) and multiplying by 100.

   Example: 14 pounds plastic / 58 pounds total = 0.24
   0.24 x 100 = 24
   24% of the trash collected was plastic
3. Students can then create a pie chart to show each percentage.
4. Wrap up. Analyze the results and have students write or discuss ways that we can reduce pollution in our beaches, rivers or neighborhoods. Here are some ways you can be part of the solution:
   - Avoid buying items with excessive packaging.
   - Purchase items in bulk instead of smaller sizes.
   - Reuse items like bags and containers instead of throwing them away.
   - Reuse boxes, envelopes, newspapers and other packing materials.
   - Reuse paper or stationery for scratch paper
   - Cut plastic six-pack holder rings lowering the risk of entanglement if they make it to the sea.
   - Hold onto your balloons! NEVER release balloons - they can end up in the ocean and be mistaken for food by hungry marine life.
   - Recycle as many items as possible like cans, bottles, newspapers, cardboard, batteries, etc.
   - Buy recycled products.
   - Keep storm drains that flow into our waterways clean.
   - Tightly secure trash in bags or trashcans.
   - Participate in local beach, river or stream clean ups.

Trash Inventory / Inventario de Basura

Type of Trash (i.e. diapers, cigarette butts, candy wrappers, etc.) / Tipo de Basura (pañales, colillas, envolturas de dulces, etc.)

Amount Collected / Cantidad Colectada

Total

Percentage / Porcentaje

Appendix L

Art and Poetry

Summary

While art is considered one of the academic disciplines, it differs from the others in that it provides students with an avenue for expressing their feelings. This activity can be done as a follow up for any field experiences or in class lessons, since it gives students the opportunity to reflect on new concepts, conservation messages, and nature itself through posters and poetry. Students are also able to display their work in their schools or in their communities.

Learning Objectives

Students will be able to:

- Learn about various styles of poetry
- Express their feelings about nature through poetry reflecting stewardship for their environment
- Use their creativity to convey conservation messages

Materials

- Writing paper or journals
- Pencils
- Construction paper
- Markers or other art supplies

Activity Procedure

Creating Poetry

1. Discuss different styles of poetry. Just a few examples include:
   - Quatrain—a traditional rhyming poetry style, containing any number of verses of four lines each. The rhyming lines may be either the 1st / 2nd and 3rd / 4th, or the 1st / 3rd and 2nd / 4th, or the 1st / 4th and 2nd / 3rd.
   - Limerick—Irish origin, a rhymed humorous or nonsense poem of five lines. The first, second, and fifth lines rhyme and contain 8 or 9 syllables. The third and fourth lines rhyme and contain 5 or 6 syllables.
   - Haiku—an unrhymed Japanese verse consisting of three unrhymed lines of five, seven, and five syllables. Haiku is usually written in the present tense and focuses on nature.
   - Free verse—irregular; no rhyme or rhythm required. There may be a pattern in line breaks—the lines may form a picture.
   - Free verse—irregular; no rhyme or rhythm required. There may be a pattern in line breaks—the lines may form a picture.
   - Acrostic-the first letters of each line are aligned vertically to form a word. The word often is the subject of the poem.

1. Wish Poem - Each line of the poem begins with the words "I wish" and then you fill in your ideas. The poem should be 8-10 lines long.
2. Have students write one or more poems about the most recent place you visited during your last field trip, or the new concepts they just learned. Poems may be either in English or Spanish. Poems themes can be as general or specific as they (or you) would like.
3. Provide guidance, but try not to give them the words.
4. If time allows, allow students to share their work with one another or with the class.
5. Poems can be written in colored butcher paper, decorated, and placed around the classroom or school.

Creating Posters

1. Explain to students that posters are great tools to convey messages, teach, or remind something to others. Many organizations and agencies use them all the time, such as the Monterey Bay National Marine Sanctuary, to help teach others about endangered animals, the deep sea, ocean pollution, etc.
2. Tell students that they will be creating group drawings or collages (your choice) to teach others about, or interpret, the new concepts they have learned. Teacher Tip: You can choose any subject for the posters after a lesson or field experience. Posters can be simple drawings or elaborate art work.
3. Students will work in pairs. Have them brainstorm about the most important thing to teach others about the subject you or they have chosen. Ask them to brainstorm ideas on how to communicate it through a poster.
4. Give them ample time to create a detailed poster. Students can use their notes, worksheets, or other handouts to use for reference. Each student must contribute at least one sentence or phrase that teaches the viewer something about the topic. Both students participate in illustrating their poster and labeling where needed.
5. Student pairs will take turns presenting their posters and their message.
6. Posters can be placed around the room or school. You can also combine all the posters to create a group mural. If possible, arrange to have your mural displayed for educational and professional presentations at the Monterey Bay National Marine Sanctuary, Elkhorn Slough National Estuarine Research Reserve, California State Parks in Monterey, or other appropriate places.

Appendix M

Family Watershed Night

Summary

The Family Watershed Night is an event that allows students to share with their family and peers what they've been doing at Watershed Academy all year. Try to align this event with another, such as Open House or other early evening event that families will be attending at the end of the year. Watershed Night is a time intensive, but worthwhile event. Students have come away from this evening feeling proud of their accomplishments and confident in communicating science. This event not only allows others, peers and family, to see what Watershed students have been doing all year, but it also makes students accountable for their knowledge and actions. While you as a teacher will be facilitating this process, students should be as responsible for getting everything developed, prepared and executed for this event.

Activity Procedure

The event may require two to three class periods for students to develop and prepared depending on what activities students choose to present.

Planning Day 1

1. Discuss Family Watershed Night. Make sure all students understand that this is their night, their projects, and their responsibility. You are there to support them as they create a night they are sure to remember.
2. Brainstorm with students what activities done through out the year they would like to share with their family. Make a list and pass out a sign-up sheet for topic options. Have students rank their choices 1-3, 1 being their first choice and 3 their last.
3. Create presentation groups. If your class has more than 16 students, create enough groups and presentations so that no group has more than 4-5 students. If working with English language learners, each group should be balanced between English and Spanish-speaking students.
4. Assign one of the presentations to each group.
5. Have students develop a materials list that you will use to ensure they are available for their next watershed preparation session. Discuss what poetry and art available can be displayed.
6. Have students work on an outline of their presentation, identifying the main messages and developing talking points. Have students choose roles and tasks for everyone in the group—who's going to say and do what. You can use the Family Watershed Night Planning sheet.
7. Discuss how to share information with their audience (i.e. be clear, make eye contact, ask questions, etc.). If time, have students practice their presentation on their group mates.

Planning Day 2 and Practice Day

1. Students will continue to work on their Watershed Night presentations. They will gather their materials, set up their stations, and do dry runs of their presentations for their group mates and the rest of the class.
2. Have students discuss the value of getting peer and expert feedback when developing a presentation.
3. Each student can complete any last minute details for their part of the presentation on index cards.

Time to set up projects!

1. A day before or hours just before the Watershed Night help students set up projects and make a list of any remaining materials they might need you to supply.
2. Student groups go through a last dry run—each student does his or her part in the presentation.
3. If time allows, have student groups present their project for the entire group.

Materials

- Family Watershed Night Planning sheets
- Any materials needed for the activities chosen by students (see each individual activity for the related materials list)

Teacher Prep

1. Photocopy Family Watershed Night Planning sheet, one per group
2. Be sure to promote the event to parents. Send out flyers and permission slips. Teacher Tip: It is recommended that you align this event with a concurrent school event, such as an end-of-year open house or fair. This will ensure parent and student attendance and participation, as well as making it easier to coordinate with the school principal and janitorial staff.
3. Once the students' projects are identified, gather all materials necessary. Sanctuary's MERITO staff will provide event development support upon request.

Family Watershed Night Planning

Activity Stations

Example
Activity Name: Watershed Model
Team Members: Maribel, Anahi, Crystal
Activity Objective/Goal: To provide a clear understanding of how our actions in the watershed directly and indirectly impact our rivers, sloughs and ocean waters.
Materials: watershed model, water
Team Members Jobs: Maribel will explain what is a watershed and the different things that contaminate it and how it all runs into the Monterey Bay National Marine Sanctuary. Anahi will sprinkle the contaminants when Maribel needs them and also spray the water at the end. Crystal will explain the solutions to each of the contaminants used. Anahi will then ask the audience for more solutions on how to protect the watershed. Everybody helps clean up.

Activity Name: ____

Team Members: ____

Activity Objective/Goal: ____
____

Materials:
____
____
____
____

Team Members Jobs:
____
____
____
____

Appendix N

Graduation: Celebrating Our Watershed

Summary

It is important to acknowledge students for their commitment to caring about watersheds and oceans. Their choice to become environmental stewards when faced with other after school programs should be highly commended. During the graduation students discuss their experiences with different scientists throughout the program and the types of science they practiced. Students are recognized for their commitment to watershed and ocean protection. The Watershed Academy program culminates with a celebration for their accomplishments of the year.

Activity Procedure

Post-Evaluation

1. Remind students about the pre-evaluation (or survey) they answered on the first day of the program. Tell students that today they will take the same survey to help the Sanctuary's MERITO program see how much they have learned through all the field trips and activities they did.
2. Hand out the post-evaluation to the students. Give students enough time to answer all the questions. Students can answer in English or Spanish.
3. Collect their evaluations when done and save for Sanctuary's MERITO staff.

Sketch a scientist

1. If your students did the "Sketch a Scientist" at the beginning of the program, then repeat the activity for comparison. Hand out Sketch a Scientist worksheet. Ask students to write their name, date and school. Have them draw their vision of a scientist at work.
2. Collect their drawings and save for Sanctuary's MERITO staff. The staff will use their pre and post Sketch a Scientist worksheets to compare their current idea of what a scientist is with their first picture.

Watershed Mini Jeopardy

1. Group students into teams of four and have them choose a name for their team.
2. Tell students that each question has a point value from 2-3.
3. Begin the game. Read the point value followed by the respective question. For example, "For three points, What are the seven main natural resources?"
4. As a rule for the game, students need to talk within their groups to come up with an answer. First group to raise their hand gets a chance to answer the question.
5. Keep track of the groups' scores on the board under their team name.
6. Game is finished when you run out of time or questions. Optional: provide prize for winning team.

Graduation ceremony

1. Present each student with a Watershed Academy certificate, free family pass to the Elkhorn Slough Estuarine Research Reserve, and "Threatened and Thriving" posters or any other available Sanctuary gifts.
2. Enjoy the rest of the day with your snacks!

Materials

- Watershed Academy post-evaluation sheet
- Sketch a Scientist worksheet (in Appendix)
- Watershed Mini Jeopardy
- Prizes
- Food or snacks for party
- Watershed Academy certificate (in Appendix or available in color upon request) Graduation gifts (provided by MERITO staff)

Teacher Prep

1. Contact Sanctuary's MERITO staff for Sanctuary gifts
2. Photocopy post-evaluations or ask MERITO staff to drop off, one per student
3. Photocopy Sketch a Scientist worksheet, one per student
4. Gather students' photos and create a poster or slide show (optional)
5. Buy snacks, drinks, and jeopardy prizes
6. Watershed Mini Jeopardy

1. Draw or explain the water cycle on the board.
   2 points

2. What is a watershed?
   2 points

3. Name four things you can do to protect your watershed.
   3 points

4. How do sand crabs help scientist know the health of the environment?
   3 points

5. What is the Monterey Bay National Marine Sanctuary?
   3 points

6. What are 3 ways the Sanctuary can become polluted?
   3 points

7. Name two natural resources in the ocean.
   2 points

8. What do you think the most serious problem threatening our oceans is?
   2 points

9. What is an endangered species?
   2 points

10. Name 3 endangered species.
    3 points

11. Name three careers/jobs in the field of science.
    3 points

12. What is an estuary?
    3 points

13. Name two animals and one plant that live in Elkhorn Slough.
    3 points

14. Explain how storm drains work.
    2 points

15. Bonus for all: What was your favorite thing about being part of the Watershed Academy?

Appendix O

Watershed Academy
Recognizes / *Reconoce a*

____

for their commitment to protecting our Earth, its watersheds and its oceans through their actions and choices every day.
por su compromiso en proteger nuestra Tierra, sus cuencas y sus océanos a travéz de sus acciónes y decisiones de cada día.

______________________	______
Watershed Academy Instructor	Date

Graduation: Celebrating Our Watershed

Calendar

Confirmed / /

Elkhorn Slough National Estuarine Research Reserve
Education Department
1700 Elkhorn Road, Watsonville, CA 95076
(831) 728-2822

School Group Reservation Request

Reservations are made by mail only.
To make a reservation, please mail the following to the address above:

- This Reservation Request Form (two sided)
- Lab and Equipment Reservation Form (two sided)
- A self-addressed, stamped envelope for your confirmation letter

Please remember that all teachers must attend the Teacher Training Workshop before they are eligible to bring school groups to visit the Reserve. Thank you!

Please print or type. Today's Date _______________

Teacher__________________________________Date attended workshop__________

School ____ Grade Level_________

Phone (school) _______________________ (home) __________________________

Home Address ____

email _________________________ The Reserve is closed Mondays & Tuesdays:

Requested Date ______________________ Alternate Dates _____________________

Arrival Time _____________________ Departure Time _________________________

Will your group be arriving by: BUS or CARPOOL (please circle one)

Number of Students ___________________ Number of Adults ___________________

(minimum ratio is 12 students : 1 adult)

(continued on other side)
12

db___

Elkhorn Slough National Estuarine Research Reserve
Page two of School Group Reservation Request

Visitation Goals: ____

____

____

Schedule: Please be specific and include time blocks for each activity you plan to do.

Will your group be using the bookstore? Yes No (please circle one)
(We request no more than 5 students with an adult at one time, in the bookstore.)

Orientation Time: ________________________________(allow 30 minutes)

Time:	Activity/Location:	#students
_________	____	
_________	____	
_________	____	
_________	____	
_________	____	
_________	____	
_________	____	
_________	____	

Does your school group have any special needs? _______________________

____

12-A
1/07

Elkhorn Slough National Estuarine Research Reserve
Lab and Equipment Reservation Form

Teachers are responsible for checking in all kits and equipment with a Reserve staff member prior to your group's departure. Please allow time for this. Teachers are also responsible for all lost or damaged equipment.

We would like to reserve the Plankton Lab: yes no
There are 12 microscopes in the Lab. Please plan your group sizes accordingly.
Samples from Kirby Park are provided.

KITS: Please indicate the number of kits you would like to reserve:

# Requested	Approved		Checked in by
__________	_________	Plankton Sample Kit: Field kit – net and jar	_________
___________	__________	Tide Monitoring Kit: 2 stakes, current meter stick, tide table	_________
___________	__________	Owl Pellet Kit: Dissected owl pellets, dissecting trays, toothpick "probes", skeleton identification materials	_________
___________	__________	One Hundred Inch Hike Kit: Five, 100 inch strings, 30 magnifying glasses	_________
___________	__________	Water Quality Monitoring Kit: (4th grade and up) Field Kit – Secchi disk, thermometers, refractometer	__________
__________	_________	Beaks & Feet For classroom use – can be checked out for one week. Contains examples of different types of bird beaks and feet with curriculum on adaptations.	_________

13

(continued on other side) 1/07

Elkhorn Slough National Estuarine Research Reserve
Page two of Equipment Reservation Form

EQUIPMENT

Please indicate the number of items you would like to reserve:

Requested	Approved		Checked in by
________	________	Binoculars (1 pair for every two students)	________
________	________	Chaperone Packs Hip packs for adult leaders with basic Field Guides, plant cards, tide book, trail maps & lists	________
________	________	Other Field Guides: Insects, Reptiles & Amphibians, Trees	________
________	________	Two-way magnifying box	________
________	________	1” Magnifying Cubes	________

Teacher’s Name ______________________________

School ______________________________

Teacher’s Signature ____________________ Date __________

ESNERR Education Dept. ____________________ Date __________

(Office use)

Lost or Damaged Equipment: ______________________________

____

Teacher’s Signature ______________________________

13- A

1/07

Appendix Q

Watershed Academy Field Trip Contacts

Camp SEA Lab
Contact: Amity Wood, Program Manager
Phone: (831) 582-3681
Email: amity_wood@csumb.edu
Web: www.campsealab.org
City of Watsonville
Contact: Tami Stolzenthaler, Environmental Education Coordinator
Phone: (831) 768-3107
Email: tstolzen@ci.watsonville.ca.us
Web: ci.watsonville.ca.us/

Defenders of Wildlife
Contact: Jim Curland, Marine Program Associate
Phone: (831) 726-9010
Email: jcurland@defenders.org
Fax: (831) 726-9020
Web: http://www.defenders.org
http://www.kidsplanet.org
http://www.defenders.org/wildlife/new/seaotters.html

Elkhorn Slough National Estuarine Research Reserve
Contact: Tricia Wilson, Visitor Center Naturalist
Mailing Address: 1700 Elkhorn Road, Watsonville, CA 95076
Phone: (831) 728-2822
Web: www.elkhornslough.org/esnerr.htm

Friends of Pajaro Dunes
Contact: John Vernon, President
Mailing Address: 2661 Beach Road, Bldg. 1, Watsonville, CA 95076
Email: info@friendsofpajarodunes.org
Web: www.friendsofpajarodunes.org

Friends of the Sea Otter:
Email: education@seaotters.org or admin@seaotters.org
Web: http://www.seaotters.org/

Monterey Bay Aquarium
Note: If you are planning a trip to the aquarium, please contact MERITO staff to schedule your visit.
Address: 886 Cannery Row, Monterey, CA 93940
Phone: (831) 648-4800
Web: www.mbayaq.org

Monterey Bay National Marine Sanctuary
Contact: Sonya Padron, Bilingual Education Specialist
Phone: (831) 647-4211
Fax: (831) 647-4244
Email: sonya.padron@noaa.gov
Web: www.montereybay.noaa.gov/educate/merito/welcome.html
Contact: Cristy Cassel, Bilingual Outreach Specialist
Phone: (831) 647-4215
Email: cristy.cassel@noaa.gov
Contact: Main Office
Phone: (831) 647- 4201
Address: 299 Foam St, Monterey, CA 93940
Web: http://www.montereybay.noaa.gov/welcome.html

Monterey Regional County Water Pollution Control Agency
Contact: Karen Harris, Community Education
Phone: (831) 645-4604
Email: commr@mrwpca.org
Web: www.mrwpca.org/html/education.html

Return of the Natives, CSUMB
Contact: Emily Smith, Restoration Coordinator
Phone: (831) 582-3687
Email: emily_smith@csumb.edu
Web: watershed.csumb.edu/ron/

Salinas Valley Solid Waste Authority
Contact: Allan Styles, Recycling Coordinator
Phone: (831) 755-1308 x 108
Email: allans@svswa.org
Web: www.svswa.org

Watershed Academy Field Trip Contacts

Save Our Shores
Contact: Laura Kasa, Executive Director
Phone: (831) 462-5660
Email: info@saveourshores.org
Web: saveourshores.org

Watsonville Wetlands Nature Center
Contact: Michelle Templeton, Nature Center Coordinator
Phone: (831) 768-1622
Email: mtempleton@ci.watsonville.ca.us
Web: www.watsonvilleslough.org/naturecenter.html

Watsonville Wetlands Watch
Contact: Jonathon, Restoration Programs
Phone: (831) 728-4106
Email: jonathan@watsonvillewetlandswatch.org
Web: watsonvillewetlandswatch.org

Wetlands Educational Resource Center
Contact: Rachel Garrett, Educational Programs Director
Phone: (831) 728-8102 x1156
Email: rachel@watsonvillewetlandswatch.org
Web: www.watsonvilleslough.org/werc.html

Whales on Wheels
Contact: Maris Sidenstecker, Program Director
Mailing Address: 1192 Waring St, Seaside, CA 93955
Phone: (831) 899-9957
Email: orcamaris@earthlink.net
Web: www.savethewhales.org

Appendix R

Watershed Academy Resource List

Books:
- The Monterey Bay Shoreline Guide
- A Natural History of the Monterey Bay National Marine Sanctuary, Monterey Bay Aquarium and National Oceanic and Atmospheric Administration Sanctuaries and Reserves Division
- Corralito's Bay, Monterey Bay Sanctuary Foundation and the Monterey Bay National Marine Sanctuary
- Pacific Intertidal Life, by Ron Russo
- In Water and Wetlands, Discover Nature, by Elizabeth P. Lawlor
- Elkhorn Slough, Mark Silberstien and Eileen Campbell
- A Field Guide to the Monterey Bay Aquarium, Monterey Bay Aquarium
- Rivers and Streams – Exploring Ecosystems, Patricia A. Fink Martin
- All the Water Birds, American Bird Conservancy
- Monterey Bay Area: Natural History and Cultural Imprints, Burton L. Gordon
- Watersheds: A Practical Handbook for Healthy Water, Clive Dobson and Gregor Gilpin Beck
- Save Our Streams: Insect and Crustaceans Key
- Sharing Nature with Children I, Joseph Cornell
- Sharing Nature with Children II, Joseph Cornell

Association of Monterey Bay Area Governments (AMBAG)-list of local representatives
444 Reservation Road, Suite G
P.O. Box 809
Marina CA. 93933
(831) 883-3750
www.ambag.org

Curriculum Guides:
- A Child's Place in the Environment
- Elkhorn Slough Teacher Guide
  1700 Elkhorn Rd.
  Watsonville, CA. 95076
  (831) 728-2822
- MARE Teacher Guides:
  Lawrence Hall of Science #5200
  Berkeley, CA. 94720-5200
  Phone: (510) 642-5008
  Fax: (510) 642-1055
  - K - Ponds
  - 1 – Rocky Seashore
  - 2 - Sandy Beach
  - 3 - Wetlands
  - 4 - Kelp Forest
  - 5 - Open Ocean
  - 6 - Islands
  - 7 - Coral Reefs
  - 8 - Polar Seas
- Project Wild
  PO Box 18060
  Boulder, CO. 80308-8060
  Phone: (303) 444-2390

- Project Wild Aquatic
  PO Box 18060
  Boulder, CO. 80308-8060
  Phone: (303) 444-2390
- Project Wet
  201 Culbertson Hall
  Montana State University
  Bozeman, Montana 59717-0570
  Phone: (406) 994-5392
  Fax: (406) 994-1919
  E-mail: rwwet@msu.oscs.montana.edu
- River Cutters, Lawrence Hall of Science
- Sea Searchers Handbook
  886 Cannery Row
  Monterey, CA. 93940-1085
  Phone: (831) 648-4800
  Fax: (831) 648-4810
  Website: http://www.mbayaq.org
- The Seaside Naturalist
  Deborah A. Coulombe
- Waves Wetlands and Watersheds
  California Coastal Commission
  45 Freemont Street, Suite 2000
  San Francisco, Ca, 94105
  Phone: (415) 904-5400
  Website: www.coastforyou.org

Websites:

www.montereybay.nos.noaa.gov -Monterey Bay National Marine Sanctuary
www.elkhornslough.org - Elkhorn Slough National Estuarine Research Reserve
www.yearofcleanwater.org - water quality monitoring
www.mbayaq.org - Monterey Bay Aquarium and activity resources
www.vims.edu/bridge/ - free online resources for teachers
http://www.mbnms-simon.org - Sanctuary Integrated Monitoring Network, marine background information and GIS graphing
http://www.farallones.org/sandcrabs/default.asp -sand crab monitoring
http://watershed.csumb.edu/ron/ - CSU Monterey Bay restoration
www.kidsdomain.com/holiday/earthday/ - Earth Day activities for children
coast4u@coastal.ca.gov - California Coastal Commission
http://www.energy.gov - U.S. Department of Energy
http://www.cnps.gov - California Native Plant Society