OUR WETLANDS, OUR WORLD

A High School Activity Guide to Upper Newport Bay

CALIFORNIA COASTAL COMMISSION

Our Wetlands, Our World

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CALIFORNIA COASTAL COMMISSION

A Project of the Community-Based Restoration and Education Program

Foreword

Located in the heart of coastal Orange County, Upper Newport Bay (UNB) comprises approximately 1,000 acres of open space—representing the largest remaining intact estuary in southern California, where an estimated 97 percent of historic wetlands has been lost. Known as one of the best birding sites in North America, UNB is a refuge for migrating birds and also supports a wide array of plant and animal life, including several endangered species. Upper Newport Bay's vegetation filters and cleans degraded water coming from a 154 square-mile watershed stretching from Santiago Oaks to the Pacific Ocean.

Unfortunately, this rich ecosystem has been seriously degraded. The area surrounding the wetland has been disturbed and converted by grazing, development, species introductions, and other human activities. Without our attention, invasive plants, which currently make up 48 percent of the Bay's flora, will out-compete and displace native species that once provided habitat. Protecting and improving the vitality of Upper Newport Bay's wetland ecosystem requires educating the Orange County community and restoring the endangered habitats.

The California Coastal Commission, whose mission is to preserve and restore the biodiversity and health of California's coastal and marine ecosystems, initiated the Marine Education Project in 2002. This project, now its own entity relying entirely on outside funding, operates the Community-Based Restoration and Education Program (CBREP) at Upper Newport Bay, a collaborative effort involving landowners and other stakeholders, including the County of Orange, the Department of Fish and Game, the City of Newport Beach, and the Newport Bay Naturalists and Friends.

The primary goal of CBREP is to protect and restore coastal habitats while creating an avenue for community involvement and education. The *Our Wetlands, Our World* activity guide for high school classrooms is part of the program's effort to promote wetlands education and restoration through hands-on learning. *Our Wetlands, Our World* is based on CBREP's premise that if people develop a personal relationship with an environment, they will be more motivated to protect it.

We invite you to share the commitment to conservation, education, appreciation, and stewardship of wetland habitats. It is critical to the viability of Upper Newport Bay that future generations understand the value of coastal habitats and participate in their protection and restoration.

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

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Acknowledgments

Curriculum Advisory Committee

Maureen Allen	*Orange County Department of Education*
Dennis Baker	*Newport Bay Naturalists and Friends*
Stephanie Barger	*Earth Resource Foundation*
Frances Cummings	*Rio Hondo University*
Kristina Finstad	*California Coastal Commission*
Annie Kohut Frankel	*California Coastal Commission*
Sarah James	*Department of Fish and Game*
Jayne Lindauer	*Santa Ana High School*
Christiane M.R. Parry	*California Coastal Commission*
Chris Raisbeck	*Sage Hill High School*
Roger Reinke	*Newport Bay Naturalists and Friends*
John Scholl	*Department of Fish and Game*
Eben Schwartz	*California Coastal Commission*
Mike Starkweather	*Corona Del Mar High School*
Grace Yick	*Orange County Harbors, Beaches, and Parks*

Curriculum Development and Adaptation

Kay Ice
Educational Development Specialists

Editors

Kristina Finstad
Annie Kohut Frankel
Christiane M.R. Parry
Eben Schwartz

Design

Mark Shepard
Shepard Associates

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Acorn Naturalists, 155 El Camino Real, Tustin, CA 92780, (714) 838-4888, www.acornnaturalists.com

Cabrillo Marine Aquarium, 3720 Stephen White Drive, San Pedro, CA 90731, (310) 548-7562 Artwork on pages 144 (bottom); 145 (top).

Frank M. Roberts, Jr., Artwork on pages 144 (top); 147 (bottom).

International Project WET, 201 Culbertson Hall, Montana State University, P.O. Box 17057, Bozeman, MT 59717-0575, (406) 994-5392, projectwet@montana.edu, www.projectwet.org

National Park Service at the Golden Gate Recreation Area, Golden Gate National Recreation Area, (415) 561-4757

National Science Teachers Association, 1840 Wilson Boulevard, Arlington, Virginia 22201-3000, www.nsta.org

Save The Bay, 350 Frank Ogawa Plaza, Suite 900, Oakland, CA 94612, (510) 452-9261, mlatta@savesfbay.org, www.saveSFbay.org

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Our Wetlands, Our World

A High School Activity Guide to Upper Newport Bay

Our Wetlands, Our World provides information and activities to help high school students learn about the importance of wetlands and to become involved in restoration of these valuable, unique environments. It also helps bring State Content Standards to life by linking science concepts to local resources. The focus of the guide is on Upper Newport Bay in Orange County; however, much of the information is applicable to other wetland sites.

Organization

The guide is divided into three sections:

I. Watersheds and Wetlands
II. Human Impacts
III. Taking Action

Each section begins with **information** on that topic written for the student. This information provides the background for many of the activities within the section.

Following the text in each section are **activities** to provide students with classroom and sometimes field experience to bring concepts to life. The activities were chosen based on several criteria, including inquiry-based learning, hands-on instruction, relation to Upper Newport Bay's specific habitats and issues, adaptability to various classroom settings, interest to students, ease of use, and correlation with State Standards.

The **appendices** at the end of the guide include:

- **UNB Inhabitant Cards**. These cards provide information on 30 inhabitants of Upper Newport Bay. There are six cards in each of the following categories: plants, birds, land animals, fish, and other marine animals. The cards are used in many activities throughout the guide. It is suggested that you photocopy the cards onto cardstock and laminate them, especially if they will be used in field studies.
- **Species Common to Upper Newport Bay.** This list shows some of the plants, birds, land animals, fish, and other marine animals common to the region. Students may see these species on a field trip to the Bay; and they can use this list to make other UNB Inhabitant Cards.
- **Resources.** The lists of organizations, wetlands, and websites can help both the students and the teacher in pursuing further knowledge and involvement opportunities available at Upper Newport Bay and other wetlands.

Activity Format

Each activity is organized as follows:

Summary. Provides an overview of the lesson and its intent.

California State Content Standards. Lists the Standards addressed in each curricular area (Science, History/Social Science, Math, English/Language Arts).

Objectives. States the goals; that is, what students will learn to do in the activity.

Materials. Specifies the materials needed to conduct the activity, such as worksheets that are included and any other materials (e.g., chart paper, soil samples, test tubes).

Preparation. Describes the steps that need to be taken prior to conducting the activity (e.g., copy worksheets, obtain water samples, set up testing stations).

Time Required. Gives the approximate amount of time needed to conduct the activity.

Procedures. Provides a step-by-step guide to conducting the activity.

Follow-up. Includes discussion questions and/or culminating actions to review students' work, highlight what students have learned, and provide closure.

Extensions. Suggests further activities to expand the study, to specifically meet your curriculum framework, and/or to apply the knowledge directly to students' community.

Field Studies

Several of the activities are labeled "Field Study" (or "Optional Field Study" or "Partial Field Study").

- Explore a Wetland (page 35)
- Wetland Soil (page 43)
- Measuring Decomposition (page 51)
- Water Quality (page 79)
- Space for Species (page 90)
- Seed Experiments (page 116)
- Plant Monitoring (page 124) *Monitoring is done March-June.*
- Stewardship (page 138) *Planting is done September-February; seed collecting is done May-August.*

These activities incorporate a field trip to Upper Newport Bay or other wetland or, perhaps, another natural site. If your class takes a field trip to a wetland site, you may want to conduct some or all of the above activities while at the site.

Some activities require samples of soil, water, or seeds from a wetland or other natural site. You can use a class field trip to Upper Newport Bay to collect samples in preparation for these activities, or if you are not planning a class field trip, you can collect all the necessary samples yourself during one visit to a wetland site. See the materials lists and preparation steps for the following activities requiring samples:

- Wetlands Soil (page 43)
- Measuring Decomposition (page 51)
- Water Quality (page 79)
- Seed Experiments (page 116)

Suggestions for Use

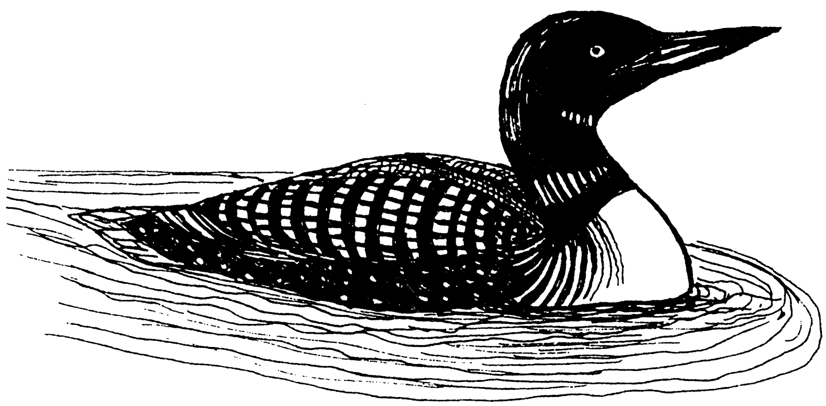
The three sections of this guide are sequential, progressing from an overview of wetlands, to the effects humans have had on these habitats, and then finally to the steps being taken to restore wetlands. Though each section is self-contained, presenting the information in this order will provide students a more complete picture.

It is suggested that you photocopy the informational text in each section for students to read and to discuss prior to conducting activities in that section. The activities are also presented in a sequential order, but each activity is a separate lesson that can be used independently. Choose those activities—and extensions—that fit your curriculum and the level and interest of your class to move students from awareness to experience and action.

A field trip to Upper Newport Bay, or other wetland, is strongly encouraged though not required for students to understand and appreciate the importance of wetlands. The first field trip activity, *Explore a Wetland,* will give students first-hand knowledge of the chosen site and will serve to engender a sense of stewardship. Taking this field trip toward the beginning of your wetlands study will also allow you to collect samples to be used in other activities.

Correlations with California State Content Standards

All activities have been correlated with California State Content Standards in Science, History/Social Science, Math, and English/Language Arts for grades 9-12. The Standards addressed by each activity are listed at the beginning of the activity. They are also presented in matrix format for quick reference in the appendix.



Contents

Watersheds and Wetlands

Watersheds

When rain falls or when snow melts, where does the water go? Where does water from your hose or sprinklers end up? Some of it soaks into the ground, but the excess water, called runoff, flows from high points to low points, eventually draining into a body of water. This drainage basin—the area through which all water flows from its highest source to a lake or ocean—is called a watershed.

Where It All Begins

A watershed starts at mountain peaks and hilltops. Snowmelt and rainfall run into mountain streams. As tributaries connect, the streams get bigger, eventually becoming rivers. As the rivers leave the mountains and reach flatter ground, the water slows and looks for the path of least resistance across the land. This path may be along a concrete channel provided for flood control. Eventually the rivers flow into a lake or ocean.

All land is part of a watershed, and the characteristics of the land greatly affect how water flows through the watershed. On heavily vegetated, relatively flat terrain, runoff is slow, and percolation—seepage—into the ground is great. In steep, bare terrain, runoff flows rapidly. Human-made features, such as dams or large paved areas, can also affect the water flow.

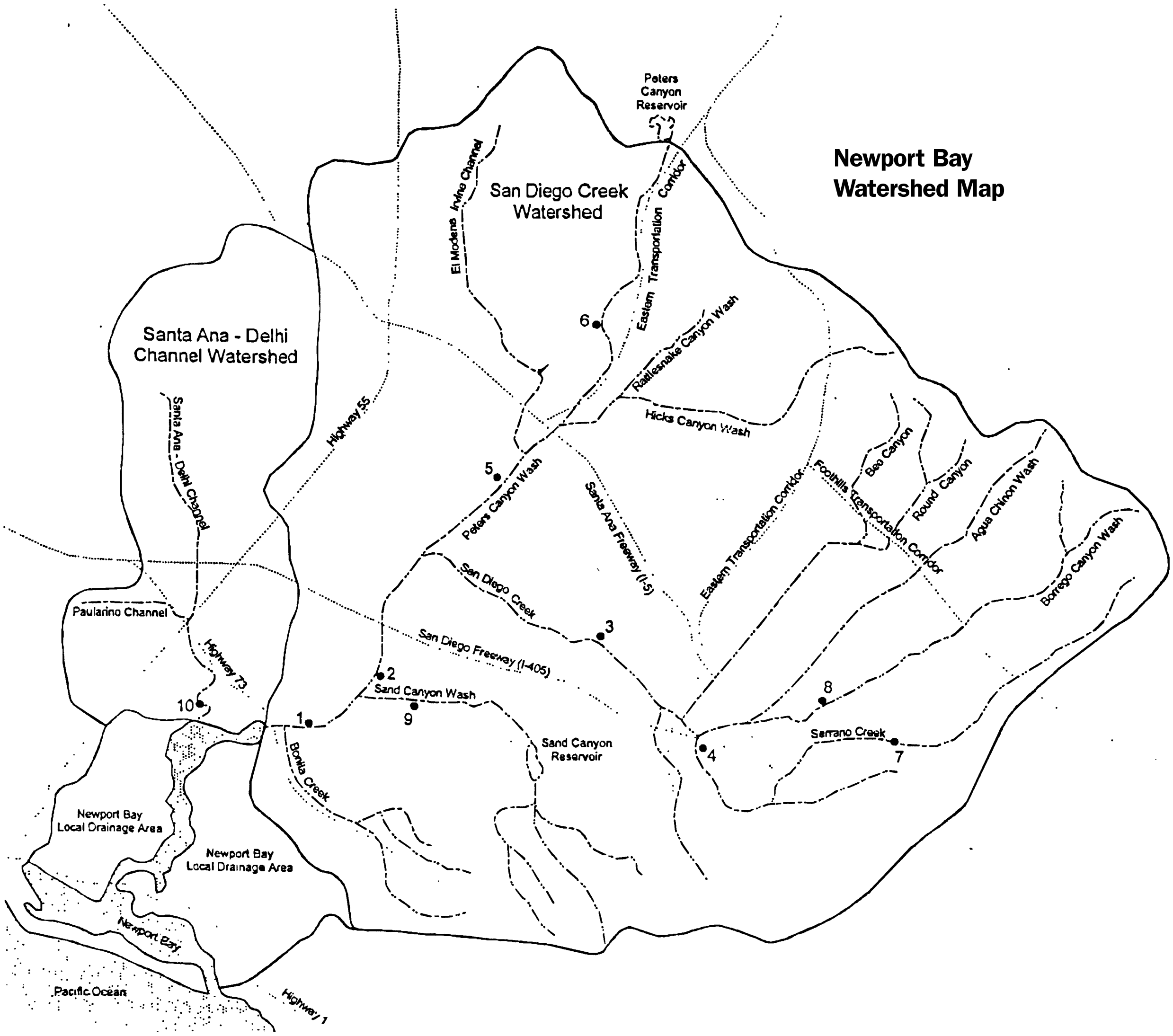
It's Not Just Water

Water flows downstream, taking with it whatever it picks up. For example, if a creek flows through an agricultural area, it can pick up fertilizer, manure, and pesticides from farming operations. In urban and suburban areas, it might gather fertilizers that wash off lawns, untreated sewage from failing sewer pipes, illegal wastewater discharges from industrial facilities, sediment from construction sites, lawn clippings and branches from yard maintenance, and oil from roads and parking lots. These pollutants may be deposited on river floodplains, may concentrate in coastal estuaries, or may drain directly into the ocean.

All land areas—agricultural, suburban, urban, and coastal—can have an impact on our fresh and marine waters. Water quality is affected by everything that goes on within the watershed.

Your Watershed

Orange County has 13 watersheds, all of them ending in the Pacific Ocean. In one of them, water drains into Upper Newport Bay from an area of approximately 154 square miles of land. This watershed extends from the Bay to the Santiago Hills and includes parts of Costa Mesa, Irvine, Lake Forest, Laguna Hills, Newport Beach, Orange, Santa Ana, and Tustin. Most of the water enters the Bay via San Diego Creek.



Wetlands

Wetlands are known by many names including swamps, marshes, mudflats, sloughs, and estuaries. Most wetlands are transition ecosystems between land and water. Each is different in its own way: some are covered with water, others are quite dry; some are saltwater, others fresh water, others a mixture of both; some are full of foliage, others appear barren; some are pool-sized, others stretch across thousands of acres.

A few generalizations can be made about wetlands. All wetlands have water present at least part of the year. Some wetlands are only damp, and some are wet only below the surface. But the presence of water leads to the two other defining characteristics of wetlands: hydric (saturated) soil and hydrophytic (water tolerant) plants.

Where In the World Are They?

Wetlands are found everywhere—along coastlines, in land-locked areas, in rural territory, and in the middle of urban areas. Precipitation and topography play key roles in the formation of a wetland. Generally, wetlands are found:

- along rivers and lakes
- near coasts and bays
- in depressions where land is lower than the surrounding landscape
- in places where groundwater seeps out of the ground
- in broad, flat areas that receive significant rainfall.

Estuaries

Many coastal wetlands, including most wetlands along the southern California coast, are estuaries. Estuaries are areas where freshwater streams meet the sea along the shores of bays and river mouths. They are the drainage point for the area's watershed. Upper Newport Bay is just such a wetland.

Estuaries like Upper Newport Bay are particularly rich, productive ecosystems for several reasons:

- The freshwater sources deposit nutrient-rich sediments into the estuary.

- The ebb and flow of the tide cause a continual mixing of the water, distributing food and nutrients throughout the Bay and maintaining a relatively high level of oxygen in the water.

- The amount of sunlight in areas like southern California coupled with the shallow water in the estuary provides ideal conditions for photosynthesis by microscopic algae.

With shifting boundaries that change with the tides, estuaries contain many habitats, from submerged marshland, to thick mudflats, to dry scrub brush. Each area accommodates the needs of different species of plants and animals, many of them adapted to the exact conditions of that habitat.

The Value of Wetlands

They used to be called swamplands and were thought to be useless. As a result, many wetlands, particularly those near population centers, were destroyed—diked, drained, and filled with soil to create buildable land. Others were converted to farmland. In California, only 9 percent of our historic wetland acreage remains. It is only recently that humans have recognized the immense value of preserving wetlands. Wetlands are now considered to be among the most productive ecosystems in the world.

Wetlands provide many benefits within a watershed, from decreasing flooding and erosion to increasing wildlife and water quality. The benefits from the wetlands in Upper Newport Bay include:

- water filtration
- habitat for animals
- recreation for people
- economic contribution.

Water Filtration

Wetlands act as filters to improve water quality. The water that flows through the watershed into wetlands contains sediment and pollutants—fertilizers, soaps, pesticides, and lawn clippings, to name a few. As water enters a wetland, it slows, which causes sediment in the water to settle out, trapping the pollutants before they reach the ocean.

Wetlands handle the pollutants in several ways. Some are buried in layers of wetland soil. Others are absorbed by plants. Within the plants and soil, biological processes can break down and convert pollutants into less harmful substances. Without the wetland, the sediment and pollutants would drain directly into the ocean. Ocean pollution as a result of runoff from land is a major environmental problem, threatening marine wildlife and human health. In recent years, polluted runoff has been responsible for numerous beach closures in southern California and elsewhere. In Orange County, education and regulations have paid off; in 2003, there were 81 beach closures—down from 137 in 2002.

Habitat

Acre for acre, there is more life in a healthy wetland than there is in almost any other kind of ecosystem, even matching the high productivity of rainforests and coral reefs. Wetlands support a tremendous variety of fish, birds, amphibians, mammals, reptiles, insects, and other animals—providing food and shelter for them all.

Wetland waters are nutrient-rich with phytoplankton, zooplankton, and the organic debris of decaying plants. Many species of juvenile and small fish, as well as insects and small crustaceans, feed on these nutrients. In turn, larger fish, mammals, birds, reptiles, and amphibians have a plentiful food supply. In the rich mud of a mudflat, many small animals—shrimp, crabs, snails, clams, and worms—live in a submerged city of tunnels and burrows.

Wetlands are havens for birds. They wade among the grasses, probing the mud for food. They swim in the open waters, scooping up fish. They soar overhead, searching the land and water for their next meal. It is estimated that 75 percent of all North American birds depend on wetlands. Migratory birds from around the world stop at wetlands to feed and breed.

Many animal species use wetlands as nurseries. Fish and shellfish such as halibut, croaker, white seabass, and shrimp return to wetlands annually to spawn. Larval and juvenile fish develop in the wetlands until they grow strong enough to venture out into the ocean. Many birds build their nests among marsh plants, and in the wetlands chicks learn to fly and to forage for food. The thick vegetation and shallow water found in wetlands provide good places to hide from predators, and the rich sources of food provide energy for young animals to grow.

Many species that depend on wetlands to survive have suffered great losses over the years as wetlands have disappeared. More than one-third of endangered and threatened species in the U.S. spend at least a portion of their lives in a wetland ecosystem.

Recreation

Wetlands aren't beneficial just for wildlife. These areas provide wonderful recreational opportunities. People come to wetlands to:

- bird watch
- photograph wildlife
- draw or paint
- walk or bike
- kayak or canoe
- fish

Besides providing a site for such activities, wetlands are available to anyone who simply wants to enjoy the wonders of nature.

Economics

Our nation's fishing and shellfishing industries harvest many species that depend on wetlands for their survival. This catch is valued at $15 billion a year.

Coastal wetlands are critical to human food supplies. These areas produce millions of tons of organic matter that provide the food for large commercial fish. And many fish consumed by people—for example halibut and seabass—use wetlands as nurseries for their young.

The Southern California Beach Valuation Project estimated that beaches in Orange and Los Angeles Counties accounted for more than $1 billion of revenues during summer 2000. Approximately 106,130 people visited Orange County beaches during this three-month period. Beaches are engines for coastal economies and cannot afford closures. Policies to improve water quality, such as wetland protection, could result in large economic gains through beach-tourism.

Upper Newport Bay

Upper Newport Bay in Newport Beach is the largest remaining estuary in southern California. It provides habitat for hundreds of species of plants and animals, including humans.

For the Birds

Upper Newport Bay is home for nearly 200 species of birds, including several rare, threatened, or endangered species, such as the Light-footed Clapper Rail, Belding's Savannah Sparrow, California Least Tern, and California Brown Pelican. The Bay is also an important stopover for migrating birds on the Pacific Flyway. During the winter months, up to 30,000 birds can be seen here on any day. It is one of the few remaining places where migrating ducks and other waterfowl can rest.

From Fish to Furry Creatures

Roughly 80 species of fish have been identified in Upper Newport Bay. Most numerous are the small fishes, such as the silvery mullet that is frequently seen jumping out of the water. Of course these small fish provide food for predators, such as the gray smoothhound shark and round stingrays. Some fish are only seasonal, using the Bay as a nursery. Some species of fish have adapted to life in the mud. Gobies and killifish seek out small pools, waiting for the tide to come back in. The long-jawed mudsucker actually burrows into the mud, where it can survive under extreme conditions of reduced oxygen and elevated temperature.

Various invertebrates live in the wetlands—bay mussels, snails, worms, shrimp, clams, and crabs, to name a few. Several species of amphibians, reptiles, and mammals can also be found in Upper Newport Bay. Frogs, snakes, lizards, squirrels, rabbits, raccoons, coyotes—all play their part in the food chain and in the ecosystem of Upper Newport Bay.

Life as a Plant

Plants are an extremely important part of a wetland ecosystem, providing both shelter and food for the animals that live there. Many of the plants in Upper Newport Bay, as in any estuary, have developed specialized ways of living in an environment that has changing levels of moisture and salinity. These plants, called halophytes, include cordgrass, pickleweed, and saltgrass—each with features that allow the plant to survive in this environment. For example, saltgrass has specialized glands that serve as saltshakers to get rid of extra salt.

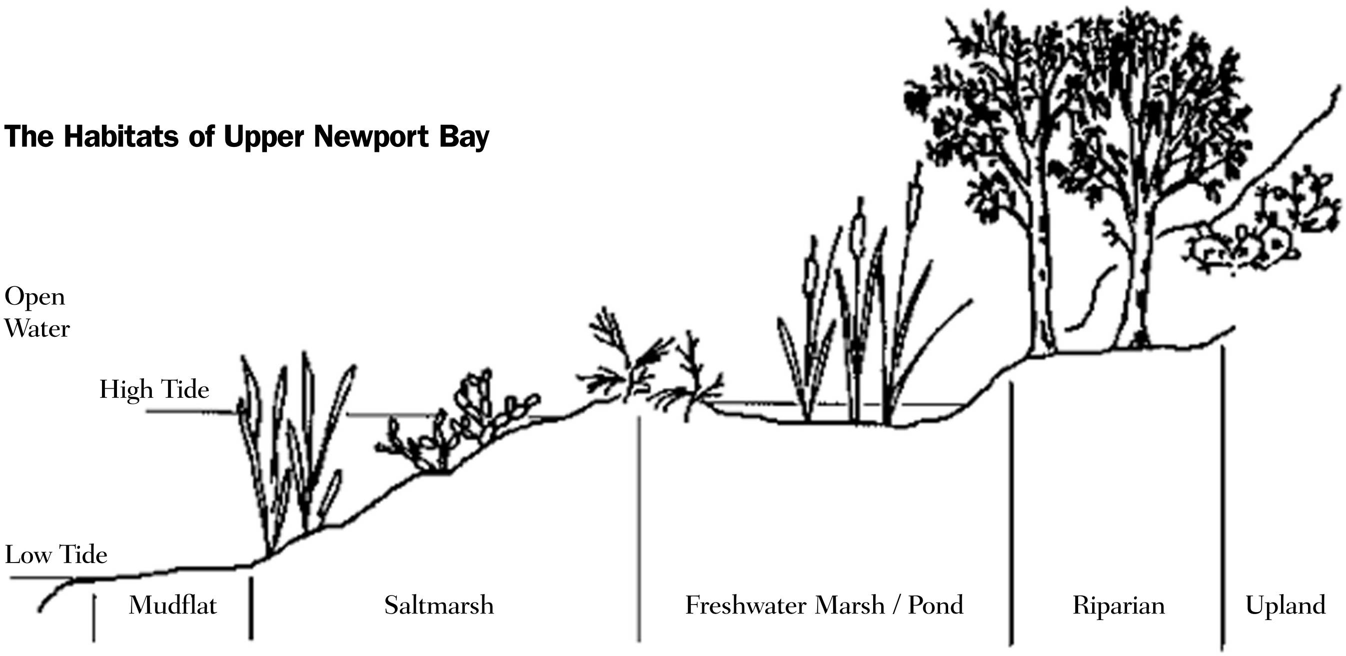
Along with the marsh plants in the Bay are rare riparian and scrub communities that include willows and sages. Upper Newport Bay is home to many native California species, which provide food and shelter for native animals. Victims of habitat loss, several of the Bay plants are protected by the Endangered Species Act.

Where to Live?

Within Upper Newport Bay, there are several habitats—places where the combination of food, water, shelter, and space allow particular types of animals or plants to survive. Though not always distinct in their boundaries, and changing in size according to daily tide fluctuation, the habitats found at the Bay include:

- open water
- salt marsh
- mudflat
- freshwater marsh
- riparian
- coastal sage scrub

The Habitats of Upper Newport Bay



Open Water — This is the actual standing water in the bay. The water is teeming with plankton. Fish—from the tiny anchovy to the large bat ray—swim in the water while ducks swim above, and osprey and other seabirds fly overhead. Aquatic plants, such as eel grass and sea lettuce, are also present.

Mudflat — When the tide recedes twice a day, the exposed shoreline becomes a mudflat—muddy, flat land. Plant life is limited to algae. But marine animals are in abundance—worms, clams, snails, crabs—and even a few fish that have adapted to the muddy conditions. Many shore birds with long pointed beaks, such as the Black-necked Stilt and Long-billed Curlew, probe the mud for a meal.

Salt Marsh — The area from the high-tide line to the mudflat is the salt marsh. Plants living in this area, such as cordgrass and pickleweed, have adapted to being periodically submerged in water and growing in salty soils. Long-legged birds, such as herons and egrets, can be seen walking along the water's edge. The elusive Light-footed Clapper rail builds its nest among the grasses and the Belding's Savannah Sparrow gleans insects from the pickleweed.

Freshwater Marsh — Water-loving plants such as cattails and sedges grow in this area, near freshwater inputs such as storm drains or creeks. Introduced species, such as the African clawed frog and mosquito fish, dominate these areas now. Dragonflies, ducks, and egrets are among the species that enjoy the marsh.

Riparian — The land alongside the creeks and other fresh water drainage points is called riparian. (*Riparian* is derived from the Latin word "ripa" meaning "streambank.") The plants here, commonly willows and cottonwood trees, like moist soil. Songbirds can be seen and heard among the foliage.

Coastal Sage Scrub — The bluffs and undeveloped mesas around the Bay provide the upland habitat. The drier slopes are home to coastal sage scrub and drought-resistant succulents such as prickly pear cactus. Snakes, lizards, coyote, rabbits, squirrels, and other critters live and hunt here. Red-tailed Hawks and Turkey Vultures often soar on the currents of warm air that arise from the bluffs.

Activity: Mapping Your Watershed

Summary: In this activity, students will become familiar with the geography of California as it relates to Upper Newport Bay's watershed by examining various types of maps. Students will travel around the classroom in small groups, visiting different map "stations" and working together to answer questions about each map.

California State Content Standards

SCIENCE

Biology/Life Sciences
- **Ecology 6b**. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Earth Sciences
- **California Geology 9a.** Students know the resources of major economic importance in California and their relation to California's geology.
- **California Geology 9c.** Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

Investigation & Experimentation
- **1h**. Students will read and interpret topographic and geologic maps.

Objectives:

Students will be able to:
- Read a variety of maps and present the information they gather from the maps
- Describe the geography of California and Upper Newport Bay

Materials:

Some or all of the following maps:

✓ Local area road map
✓ Newport Bay/San Diego Creek Watershed Map (*from "Watershed and Wetlands" background information*)
✓ Orange County Wetlands map (*http://www.ocwatersheds.com/watersheds/intro_wetlands.asp*)
✓ Aerial maps of Newport Bay and San Diego Creek Watershed (*http://www.ocwatersheds.com/watersheds/intro_aerial.asp; 714-973-6694*
✓ *Note: San Diego Creek Watershed drains into Newport Bay Watershed)*
✓ Nautical charts of Newport Bay Area (*http://maptech.com*)
✓ Topographical map of local area (*http://mapping.usgs.gov http://maptech.com*)
✓ Orange County Green Map (*www.ocfohbp.org; 949-399-3669*)

Handout
Map Questions

Preparation:

Make a copy of the questions for each map. Place maps around the classroom; tape the appropriate list of questions next to each map. Number each map station.

Time Required:

Approximately 1 hour

Procedures:

1. Divide the class into equal groups according to the number of map stations you have and instruct each group to stand by a station.

2. Explain that each group will have a few minutes at each station to use the map(s) to answer the questions posted at that station. Instruct each group to record its answers.

3. Tell students to stay at their station until you signal them to go to the next station.

4. Judge the amount of time at each station according to the number of stations and students' abilities. Continue the activity until every group has visited every map station.

5. Have each group present one of the maps and discuss their findings. Compare their answers with those of the rest of the class.

Alternative Procedure *(generally for more advanced students):*

1. Instead of placing questions next to each map, select questions from the Map Questions handout and make your own list of questions for each student or group.

2. Explain that students are to answer each of the questions by finding the appropriate map. Review the types of maps displayed.

3. Allow students time to circulate around the room and write answers to their questions.

4. When all students have finished, read through all the map questions, having students share their answers.

Follow-up:

Use the following questions to ask students what they learned from the maps.

1. What area constitutes the watershed for Upper Newport Bay?
   (The entire San Diego Creek Watershed drains into Upper Newport Bay.)

2. Is the watershed primarily "green" areas or "developed" areas? What makes up each of these areas?
   (The watershed is primarily developed, including houses, businesses, schools, streets and highways.)

3. How does water flowing through the watershed create problems in the Bay?
   (All of the water that runs off into San Diego Creek, and all of the pollutants that the runoff collects, end up in Upper Newport Bay. That includes all kinds of litter and debris, fertilizer, animal wastes, pesticides, oil, detergent, paint, and anything else that finds its way into the runoff. These pollutants disturb the food web and ecosystem balance in the Bay.)

4. What can you do to help improve the Upper Newport Bay watershed?
   (For example:
   Keep cars well maintained and free of leaks.
   Recycle used motor oil.
   Do not pour chemicals on the ground or down storm drains.
   Properly dispose of trash in garbage cans.
   Pick up pet waste.
   Don't dispose of leaves or grass clippings in the storm drain; try composting yard waste.
   Landscape yards with native, drought-tolerant plants that do not require fertilizer .
   Prevent runoff by not over-watering.
   Avoid allowing even clean water to run off into gutters.
   Try "natural" [non-toxic] pest control.)

Extensions:

1. Demonstrate the sources of pollution in a watershed using an interactive, tabletop model. See http://www.ocwatersheds.com/PublicEducation/EnviroScape.asp or call the Orange County Stormwater Program at (714) 567-363 to learn more about the EnviroScape Model.

2. Have students view a PowerPoint slide show on Watershed Science at *http://www.ocwatersheds.com/PublicEducation/pe_other_materials.asp.*

Adapted from "Mapping Your Watershed" from *Save San Francisco Bay Watershed Education Program*, www.saveSFbay.org

Map Questions

Local Area Road Map

1. Locate your school on the map. What is the shortest route to Upper Newport Bay on roads and highways?

2. How many miles would you need to travel along roads from your school to the Bay? How many miles would it be if you could go straight "as the crow flies"?

3. Locate parks, wildlife refuges, and preserves on the map. Which ones have you visited? About what percentage of the map contains these "green" areas? What percentage is "developed," that is, with houses, business, schools, streets, highways?

4. Locate the Orange County Airport on the map. Why do you think the airport is built on an historic wetland site? What effects do you think the airport has on the Bay?

Orange County Topographical Map

1. What do the contour lines on the map represent? Where are the highest and lowest points on the map?

2. Locate the creeks and channels that flow into Upper Newport Bay.

3. What is the length of San Diego Creek?

4. A creek's "watershed" is the area of land that sheds water to the creek. The watershed for a creek is defined by the ridge lines (highest points) that separate it from another creek's watershed. What areas drain into San Diego Creek?

5. Can you find any roads on the map? How are these different from and similar to the creeks?

6. Where would pollutants running off your school parking lot flow?

Newport Bay/San Diego Creek Watershed Map

1. What cities' runoff drains into Newport Bay?
2. Is your home located in the Newport Bay/San Diego Creek watershed?
3. Where might pollutants that drain into the Bay, including sediment, originate?

Nautical Chart of Newport Bay

1. Maps can be made to highlight different features. For example, some maps highlight landforms while others highlight roads and highways. What does this map highlight? Why would you need a Nautical Chart?
2. What do the small black numbers on this map represent? Why do you think these numbers might change? How frequently, and in what locations, do you think these numbers vary?
3. Locate the Pacific Coast Highway Bridge, Shellmaker Island, Big Canyon, the Salt Dike, Least Tern Island, and the San Diego Creek drainage point.
4. What is the average depth of Upper Newport Bay? Where are the maximum and minimum depths?
5. How do you think the depth has changed over time?
6. How might global climate change affect the habitat distribution at Upper Newport Bay?

Orange County Wetlands Map

1. How many wetlands are there in Orange County?
2. What percentage of wetlands are estuaries—where the land meets the ocean?
3. Which wetlands are largest?
4. Which estuaries drain the largest watershed?

Aerial Map of Newport Bay Area
or
Detailed Road Maps

1. Where does fresh water enter Newport Bay?

2. What might be picked up by water on its way into the Bay? What problems might this runoff cause?

3. Where does salt water come into Newport Bay?

4. What kind of water would you expect to find in the Bay?

Orange County Green Map

1. Find the following waterways:
   - Aliso Creek
   - Carbon Creek
   - Coyote Creek
   - San Gabriel River
   - San Juan Creek
   - Santa Ana River
   - Santiago Creek
   - Trabuco Creek

   Where does each creek or river eventually lead?

2. Locate the San Diego Creek Watershed. Where is San Diego Creek (Peter's Canyon Corridor) in the watershed?

3. Are the areas that drain into San Diego Creek mainly "green" or "developed"?

4. Where does San Diego Creek flow into?

5. If a watershed is compared to a bathtub, what part of the bathtub is the Bay?

Activity: Wetland Habitats

Summary: This activity uses a flow chart and habitat cards to introduce and classify common types of wetlands.

California State Content Standards

SCIENCE

Biology/Life Sciences
- **Ecology 6e**. Students know a vital part of an ecosystem is the stability of its producers and decomposers.

Investigation & Experimentation
- **1g**. Students will recognize the usefulness and limitations of models and theories as scientific representations of reality.

Objectives:

Students will:
- Classify wetlands based on their characteristics.

Materials:
- *UNB Inhabitant Cards* (Appendix A)
- Map of the United States
- *(optional)* Pictures of wetlands (from books, magazines, internet)
- Handouts
  - *Wetland Habitats Flow Chart*
  - *Habitat Cards*

Preparation:
- If necessary, review the use of a flow chart, practicing as a group with one of the pictures.
- Make a copy of the *Wetland Habitats Flow Chart* for each student or group

Option 1 – see Procedures
- Make a copy the *Habitat Cards* for each group.

Option 2 – see Procedures
- Make one copy of the *Habitat Cards*, cut them apart, and place them at various stations around the room, perhaps with photos of that wetland habitat.

Time Required:
- Approximately 45 minutes

Adapted from "Wetland Habitats" from *WOW! The Wonders of Wetlands*, co-published by International Project WET and Environmental Concern

Procedures:

1. Discuss wetlands with students. Explain that wetlands are classified, in part, by the type of water, frequency and degree of inundation, and types of vegetation most prevalent there.

2. Tell students that they are going to use a flow chart to identify ten wetland types by the habitats they provide.

3. Divide the class into groups and distribute to each group a copy of the *Wetland Habitats Flow Chart*.

4. Proceed with Option 1 or 2 below:

Option 1

Distribute a copy of the *Habitat Cards* to each group. Have each group use the *Wetland Habitats Flow Chart* to identify the ten wetlands described on the *Habitat Cards*.

Option 2

Tell students that around the room are descriptions and pictures of various types of wetlands. Explain that they are to move from station to station and use the flow chart to identify each type of wetland.

Follow-up:

1. Have students share their answers, discussing any discrepancies.
   (See Answer Key.)

2. Have students use the *UNB Inhabitant Cards* and the flow chart to classify the wetlands in Upper Newport Bay.

3. Using a map of the United States, have students discuss where the different wetland types might appear.

4. From what they have read on the *Habitat Cards*, have student identify the value of wetlands.

Answer Key:

1. sandy beach
2. shrub swamp
3. aquatic plant bed
4. wet meadow
5. mud flat
6. tidal freshwater marsh
7. forested wetland
8. seagrass bed
9. bog
10. salt marsh

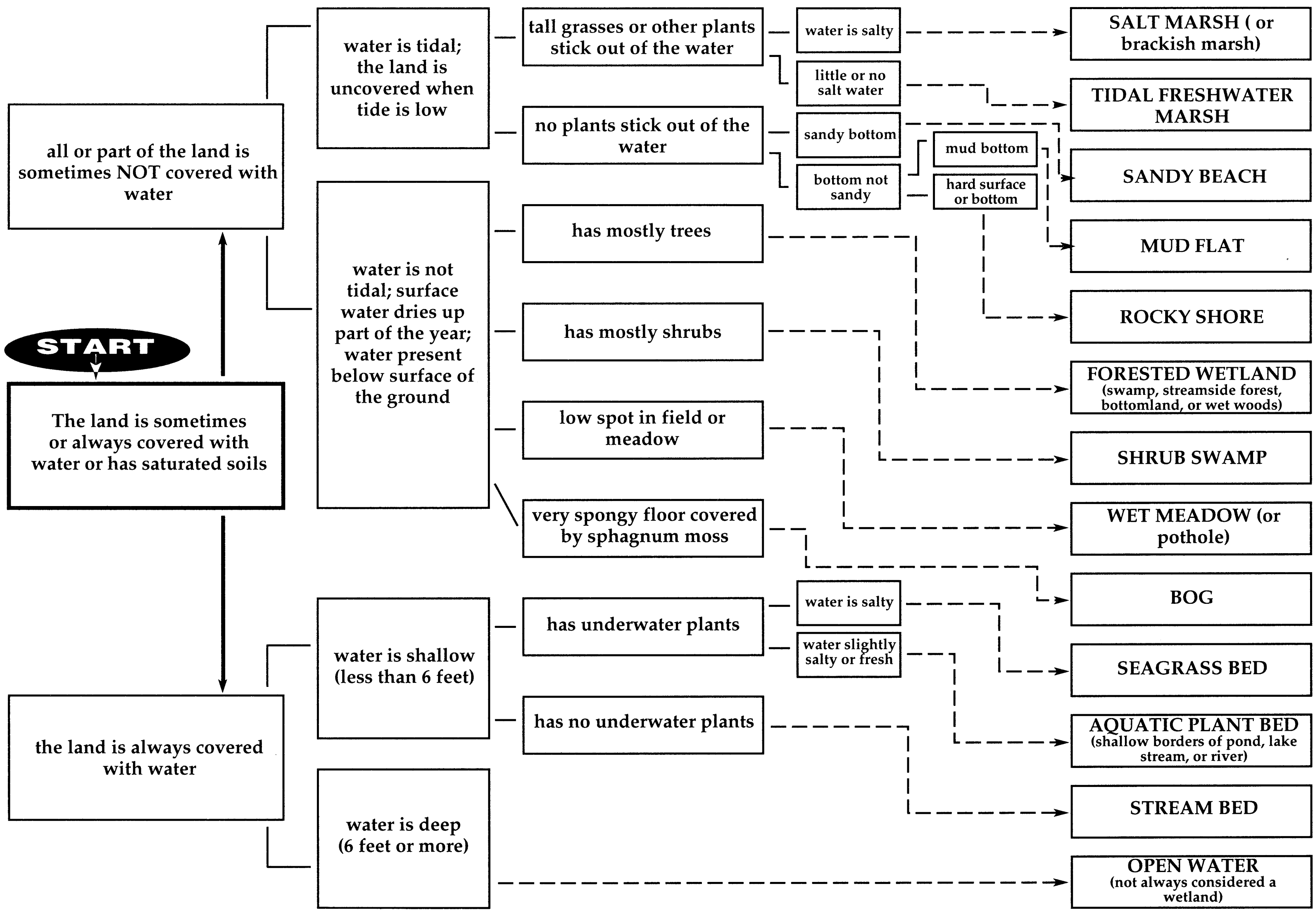
Extensions:

Make a list of several organisms that live in the various habitats. Randomly assign organisms to student groups and have them determine the likely habitat for each organism and explain why.

Adapted from "Wetland Habitats" from *WOW! The Wonders of Wetlands*, co-published by International Project WET and Environmental Concern

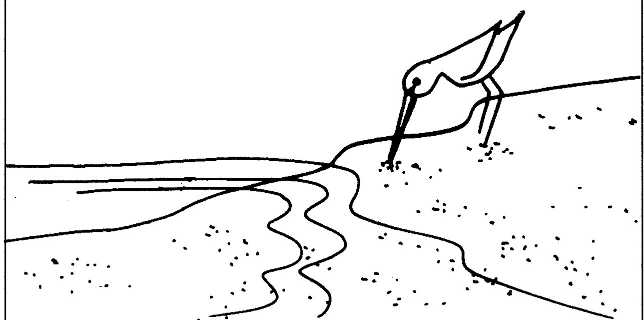
Wetland Habitats Flow Chart

Carefully read each of the habitat cards, then use this flow chart to identify each habitat. Start at the left side of the page at the first box. There are two boxes connected to that box—choose the one that matches the description on the card. Then move on to the next set of boxes, following the lines, and make another choice. Continue until you reach the name of the habitat described on the card. Can you identify all ten habitats?



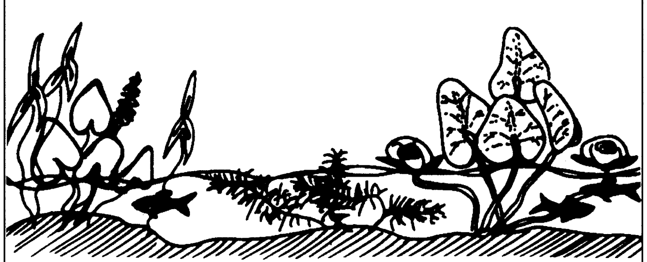
Habitat Cards

1. During storms, the waves push grains of sand into ever-changing patterns. During low tide the animals that live among the sand grains feel the summer heat or the winter cold. Shore birds search along the water's edge for these animals and for bits of food that wash in from the water. No plants grow here.



2. Scrubby, low-growing thickets of shrubs grow here, in places that may have started out as wet meadows. You might find these places near the coast, or where lakes, streams, rivers, marshes, and forested swamps overflow. They are not always covered with water. This type of wetland offers good habitat for fish, reptiles, amphibians, and many other animals.

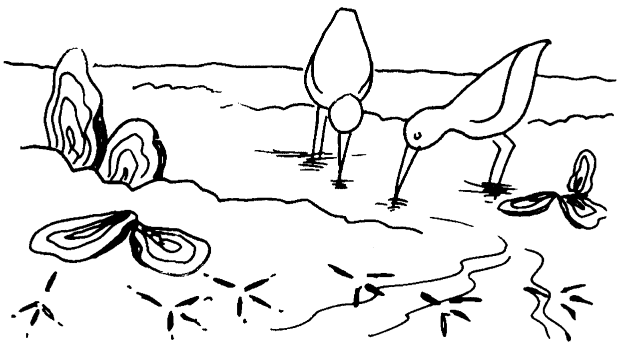
3. In the shallow borders of ponds, lakes, rivers, and streams, where there is good light and the water has little salt, underwater plants and plants with floating leaves grow. Some of these plants are valuable food for many kinds of waterfowl including ducks, geese, and swans. All make places for little fish and other animals to live and feed. These plants slow water movement and protect the soil on shores and banks from erosion.



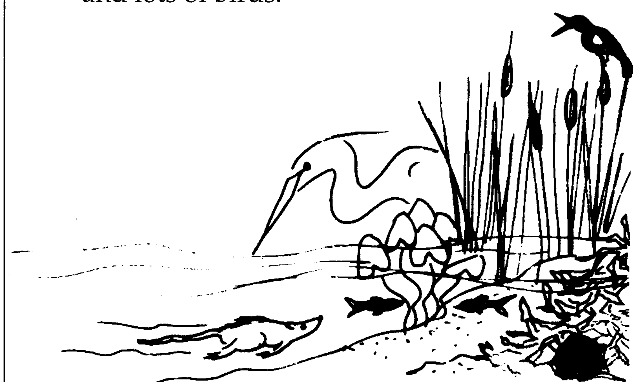
4. Depressions in the ground may fill with rain and ground water and stay wet for several days or weeks. Landowners often mow or plow around these spots to avoid getting tractor wheels stuck in the soft ground. On spring evenings, these puddles seem alive with the high-pitched calls of spring peepers (tiny frogs) looking for mates among the rushes and sedges that grow here. In the heat of the summer, these places usually dry up.

Habitat Cards

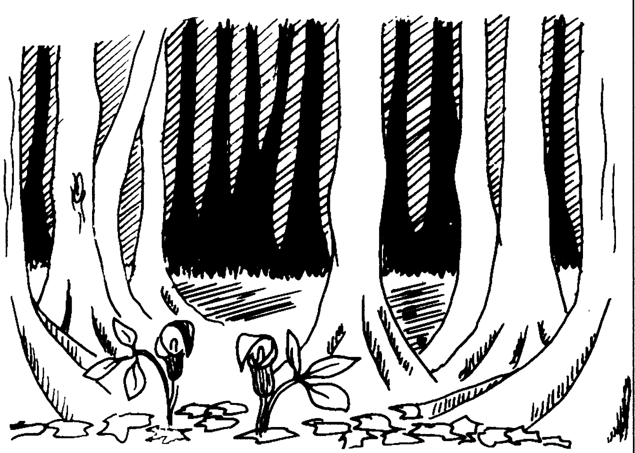
5. Fine particles of dirt make mud when they settle out of the water. Where the water is very shallow, the muddy bottom is uncovered at low tide. While this area may not look like home to many animals, and few or no plants grow here, lots of creatures live down in the mud. Watch for hungry shore birds searching for them in the mud.



6. Tall grasses and other kinds of plants grow up out of the water. The water contains little or no salt, but the push of incoming tides is strong enough to raise the water level in the river. The ground is sometimes flooded and sometimes dry or exposed. The plants provide food and places to hide for many kinds of animals including fish, invertebrates, muskrats, and lots of birds.



7. Where trees grow in low-lying areas, the ground may hold water for part of the year. In the spring, many beautiful wildflowers grow here, and frogs and salamanders find wet places to lay their eggs.



8. In salty bays or at the ocean's edge, two kinds of plants may grow under the shallow water. They can only live where it is shallow because they are rooted on the bottom and need light to make food. The plants are eaten by many animals, and many of them find safe places to live among the plants. These plants protect the shore and reduce the muddiness of the water by slowing the waves.

Habitat Cards

9. Old lakebeds and other low areas that fill with rainwater sometimes accumulate layers of partially decayed plants called peat. At first glance these places might look dry, but their moss-covered floors actually hold a good deal of fresh water just below the surface. The ground here feels very spongy. Some shrubs and evergreen trees also grow above the sphagnum moss. In these unusual conditions, many unique, beautiful, and rare plants and animals can be found.

10. Along the shore where the water is salty, tall grasses grow up out of the water. Tides move in and out, but some places are flooded only during storms and very high tides. When the tough plants here die, they break down in the water to form little particles called detritus. Many animals eat detritus by filtering it out of the water.

Activity: Explore a Wetland

(Field Study)

Summary: Students explore a local wetland, learning about different characteristics of the wetland and the plants and wildlife it supports.

California State Content Standards

SCIENCE

Biology/Life Sciences

- **Ecology 6a.** Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
- **Ecology 6e.** Students know a vital part of an ecosystem is the stability of its producers and decomposers.

Investigation & Experimentation

- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- **1j.** Students will recognize the issues of statistical variability and the need for controlled tests.
- **1k.** Students will recognize the cumulative nature of scientific evidence.

Objectives:

Students will be able to:

- Identify the habitats of the wetland
- Describe different organisms that live in the wetland

Materials:

- Field guides
- Clipboards
- Collecting dishes and jars
- Hand lenses and/or magnifying glasses
- Binoculars
- Digital camera
- *UNB Inhabitant Cards* (Appendix A)
- Handout
  - *Field Notes Worksheet*

Preparations:

- Make a copy for each student or group of the *Field Notes Worksheet*.
- Contact the wetland you plan to visit (see list in Appendix D) to obtain permission for access and to find out what specific areas students can focus on, what equipment and materials may be borrowed, and what activities are available at the site.
- Use this field trip to the wetland to prepare for or in conjunction with other activities. See:
  - Wetland Soil
  - Measuring Decomposition
  - Water Quality
  - Space for Species
  - Seed Experiments
  - Plant Monitoring
  - Stewardship

Time Required:

- The amount of time required will vary between a minimum of one hour to a full day, in addition to follow-up after the field trip.

Procedures:

BEFORE THE FIELD TRIP:

1. Inform students that they will be taking a field trip to a wetland and that they will be acting as field biologists for the trip, exploring the ecology of the wetland.

2. Review each of the items on the *Field Notes Worksheet.*

3. Encourage students to study the *UNB Inhabitant Cards*.

AT THE WETLAND SITE:

1. Remind students that wetlands are fragile and rare ecosystems that are easily damaged. Review some behavior rules:
   - Do not feed the wildlife.
   - Do not disturb any form of plant or animal life.
   - Do not collect specimens unless you have permission.
   - Do not walk on the mudflats.

2. Determine how you want students to explore and make observations: all groups in all areas or each group in a separate area; on foot or in canoes/kayaks or both.

3. Tell students that field guides and the *UNB Inhabitant Cards*, along with collecting jars and hand lenses, are available to help them identify organisms they find.

4. Remind students to spend time quietly observing—listening, watching, smelling, touching.

5. Hand out a copy of the *Field Notes Worksheet* to each student or group.

AFTER THE FIELD TRIP:

Have students compare and discuss their *Field Notes Worksheets.* Use the following questions to help generate discussions.

a. Did the weather and the tide have any effect on what you saw at the wetland?
b. How might the wetland change with the seasons?
c. Did you discover any plants or animals that you didn't expect to find? Any that you haven't been able to identify?
d. Which habitat had the highest biodiversity among animal and plant species?
e. What food chains exist among the organisms you saw in the wetland?
f. How do humans use and affect the wetland?
g. How would the information you gathered be useful to biologists?
h. Were there differences among students' *Field Notes Worksheets*? Why?

Extensions:

1. Have students create a virtual wetlands PowerPoint lesson for lower grades.
2. Tour other wetlands and compare their ecology. (See Appendix D.)
3. Visit the Peter and Mary Muth Interpretive Center. Call 949- 923-2290 for information.

Field Notes Worksheet

Wetland Name/Location: ______________________________

Date:______________________ **Time**: ______________________

General Observations:
Spend 5 minutes quietly observing. What do you see, smell, hear, and feel?

Weather

Temperature: ______________________ Cloud Cover: ______________________

Wind: ______________________ Other: ______________________

Tide

High or low: ______________________ Coming in or going out: ______________________

Geology

What signs of tectonic shifting can you identify?

Habitats, Animals, Plants

Habitat Include brief description.	**Animals** List animals seen in each category in each habitat, including how many and what they were doing. Be sure to include humans under mammals.	**Evidence of Animals** (tracks, burrows, droppings, nests, etc.)	**Plants** List plant species. Indicate **S**carce or **A**bundant **N**ative or **I**nvasive Describe adaptations for that habitat.
	mammals birds fish invertebrates reptiles		

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	birds fish invertebrates reptiles		
	mammals birds fish invertebrates reptiles		
	mammals birds fish invertebrates reptiles		

Water

Describe and sketch any organisms you see in a sample of the water. How do the organisms move? Do the organisms interact?

Threats

What evidence do you see of threats to the habitats?

Activity: Wetland Webs

Summary: Students learn about the inhabitants in wetlands and construct a typical wetland food web to discover the interconnectedness of the ecosystem.

California State Content Standards

SCIENCE

Biology/Life Sciences

- **Ecology 6e.** Students know a vital part of an ecosystem is the stability of its producers and decomposers.
- **Ecology 6f.** Students know at each link in a food web some energy is stored in newly made structures but much energy is dissipated into the environment as heat. This dissipation may be represented in an energy pyramid.

ENGLISH-LANGUAGE ARTS

Grades 9-10

Reading Comprehension

- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.3.** Generate relevant questions about readings on issues that can be researched.
- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.5.** Extend ideas presented in primary or secondary sources through original analysis, evaluation, and elaboration.

Speaking Applications

- **Deliver Expository Presentations 2.2**
  b. Convey information and ideas from primary and secondary sources accurately and coherently.
  e. Anticipate and address the listener's potential misunderstandings, biases, and expectations.
- **Apply Appropriate Interviewing Techniques 2.3**
  a. Prepare and ask relevant questions.
  b. Make notes of responses.
  d. Respond correctly and effectively to questions.
  e. Demonstrate knowledge of the subject or organization.
  f. Compile and report responses.
- **Deliver Descriptive Presentations 2.6**
  a. Establish clearly the speaker's point of view on the subject of the presentation.
  b. Establish clearly the speaker's relationship with that subject (e.g., dispassionate observation, personal involvement).
  c. Use effective, factual descriptions of appearance, concrete images, shifting perspectives and vantage points, and sensory details.

Grades 11-12

Listening and Speaking Strategies

- **Organization and Delivery of Oral Communication 1.8.** Use effective and interesting language, including:
  a. Informal expressions for effect
  b. Standard American English for clarity
  c. Technical language for specificity.

Objectives:

Students will be able to:

- Identify wetland inhabitants
- Identify the various roles within in a food web
- Explain the concept of interconnectedness

Materials:

- *UNB Inhabitant Cards* (Appendix A)
- Notepads and pencils
- Chart paper or butcher paper

Preparations:

- Have several sheets of chart paper or lengths of butcher paper available for each large group of students.

Time Required:

- Approximately 50 minutes for each of the two activities; additional time for research

Procedures:

Conduct the following activities with the *UNB Inhabitant Cards* to help students learn about the plants and animals that inhabit Upper Newport Bay and discover the relation of one species to another in a wetland food web.

Each One Teach One:

1. Hand out one or more of the *UNB Inhabitant Cards* to each student. Give students time not only to learn the information on their cards but also to conduct outside research to learn other facts about the inhabitants on their cards.
2. Explain to students that they are to interview other students about the inhabitants of Upper Newport Bay and that, in turn, they will be interviewed about their species. Ask students to keep a list of the inhabitants within each of the following categories: plants, birds, land animals, fish, other marine animals. Have students determine how they might categorize the species in each list, for example by habitat or by trophic level.

Build a Food Pyramid, Food Chains, Food Webs:

1. Discuss the various roles within a food web:

   - primary producers (autotrophs—which covert energy from the sun)
   - primary consumers (herbivores—which consume primary producers)
   - secondary consumers (carnivores—which consume primary consumers and other secondary consumers)
   - detritivores (micro- and macroorganisms that decompose dead plant and animal matter)

   Point out that organisms within a community interact with each other and with the abiotic, non-living, environment—that is, sun, soil, water, inorganic nutrients, etc. Explain that the passage of energy from one organism to another takes place along a particular food chain—that is, a sequence of organisms related to one another as prey and predator. Ask students to give examples of simple food chains. For example:

   Shore birds eat clams.
   Clams eat plankton.
   Zooplankton eat phytoplankton.
   Phytoplankton are dependent upon nutrients in the water and the sun for energy to make their own food through photosynthesis.

2. Tell students that in most ecosystems, food chains are linked together in complex food webs, with many interconnections. Explain that webs may involve more than 100 different species, with predators taking more than one type of prey, and each type of prey being exploited by several different species of predator. Emphasize that the connection between species in a food web can make or break the function of the ecosystem.
3. Hand out one or more *UNB Inhabitant Cards* to each student. Have students use the information on the cards to build a "food pyramid" from the primary producers up. Ask students how the number of species in the bottom levels compares to the number of species at the top level. Ask why they think the pyramid is shaped this way. Point out that a large body often requires a more abundant food source and a larger habitat.

4. Next, divide the students into large groups and have them lay out their cards on the chart or butcher paper to create food **chains**. Ask them to write the name of their species on the paper and to draw arrows pointing to what is consumed.
5. Combine groups and have them compare their food chains and now create food **webs** showing how the chains are interconnected.
6. Demonstrate ecosystem stability by adding or removing food web connections.

Follow-up:

After the activities, ask students to share and explain their food webs. Ask the following questions to generate a discussion:

1. How does the size of the organism generally relate to its position in the food web?
   (In general, the larger the animal, the higher it is on the food web.)
2. Did you note any exceptions to this generalization?
3. What other connections, besides predator-prey, hold an ecosystem in balance? *(Mutualism is common in nature, and species depend on one another for more than just a meal. Pollinators and animals provide dispersal mechanisms; microbes and roots provide soil aeration; plants provide protection, shelter, and nesting refuge; etc.)*
4. What could happen to the food web if a hazard, such as an oil spill, occurred?
   (Food webs are fragile, and the removal of even one link in the chain may ultimately result in the collapse of the entire food web. For example, an oil spill may block out the sun and disrupt photosynthesis in phytoplankton, decreasing the amount of plankton in the water. Clams then cannot find enough to eat and their numbers will decrease. And ultimately, the shore birds that eat the clams will have to find some other food item, move to another habitat, perhaps forgo reproduction that year, or maybe even starve.)
5. Why would the disruption and possible destruction of a marine food web matter to us?

Extensions:

1. Make more *UNB Inhabitant Cards*. The *UNB Inhabitant Cards* represent only a small portion of the organisms in Upper Newport Bay. There are, for example, more than 200 species of birds. Have students research other species at the Bay within each category and make cards to match the existing *UNB Inhabitant Cards*. (See the list of *Species Common to Upper Newport Bay* in Appendix B.)
2. Build a food chain for each of the foods in a meal, e.g. a student's lunch. Think about the energy transfer required to produce one pound of beef versus one pound of rice, or a spiny lobster versus a bluefin tuna.

Activity: Wetland Soil

Summary: Students learn about the properties of wetland soils and about the organisms that live in wetland soil.

California State Content Standards

SCIENCE

Biology/Life Sciences

- **Ecology 6d.** Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.

Investigation & Experimentation

- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- **1g.** Students will recognize the usefulness and limitations of models and theories as scientific representations of reality.
- **1i.** Students will analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
- **1j.** Students will recognize the issues of statistical variability and the need for controlled tests.
- **1k.** Students will recognize the cumulative nature of scientific evidence.

ENGLISH-LANGUAGE ARTS

Grades 9-10

Reading Comprehension

- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.3.** Generate relevant questions about readings on issues that can be researched.

Objectives:

Students will be able to:

- Classify soil according to color
- Describe conditions that create the color characteristics of wetland soils
- Describe organisms that live in the soil and their interrelationships

Materials:

- 3 or more soil samples from various areas and depths in a wetland
  (Likely locations for wetlands include the edges of ponds and streams, low lying topography that is often wet and muddy, drainage ditches that are frequently full of water, or sites with obvious wetland vegetation—e.g., cattails and reeds. See Appendix D for southern California wetlands.)
- Several packs of 64 Crayola® crayons
- Poster board or manila folders
- Handouts
  - *Wetland Soils*
  - *Wetland Soils Color Chart*
  - *Field-Based Soil Sample Data Chart*
  - *Analyzing Soil Samples Worksheet*

Note: The activity "Measuring Decomposition" also requires soil samples. Consider collecting samples for both activities concurrently.

Preparations:

- Collect soil samples from 3 different locations at the wetland—mudflat, water's edge, and upland area. (**Note**: A soil probe will extract a deep narrow sample with minimal disruption of the landscape, but it does not work well in dry soil. A garden trowel may be used, but obtaining a continuous sample will be difficult.)
  - Call the site to verify that you can take soil samples and to inquire about what tools and assistance are available for collection.
  - At each location, remove a scoop of soil about the size of a Ping Pong ball at two-inch intervals to a depth of eighteen inches.
  - Place each sample in a specimen jar or zip-top bag and label with the location and depth of the sample.
  - Refill the hole.

Alternatively, have students collect and label samples on a field trip to the wetland.

- Make a copy for each student of the *Wetland Soils* handout.
- If taking students on a field trip to the wetland, make a copy for each group of the *Soil Sample Data Chart.*
- Make a copy for each group of the *Wetland Soils Color Chart.*
- Make copies of the *Analyzing Soil Samples Worksheet* for each group (one copy for each soil sample to be analyzed).
- Set up three stations in the room, each with a microscope and the soil samples from each area.

Time Required:

- Approximately 60 minutes for lesson plus time to collect soil samples or take optional field trip.

Procedures:

1. Read the following description of a land area to students and ask if they would classify it as a wetland.
   "The land contains some long-leafed plants that look like grasses. Most of the year the land is dry; however, almost every spring the area is flooded."

2. Tell students that wetlands have three characteristics that make them unique habitats: there must be **water** present for a sufficient period of time to establish **hydrophytic plant species** and to influence the development of **hydric soils**. Point out that because of regular flooding in the example above, one would assume that the plants are hydrophytes; however, a soil test could confirm whether the area deserves wetland classification.

3. Tell students that soils are often used to determine whether or not an area is a wetland. Show students three soil samples of varying colors. Ask students how they would classify them or distinguish one from the other.

4. Tell students that color provides important clues used by scientists when classifying soils. Explain that wetland scientists use a complex set of color charts—a Munsell soil color book—to classify soils into different types based on color, lightness and darkness, and the degree of mixture of colors. Tell students that because wetland habitats are rare, there are laws protecting wetlands from development or other disturbances; therefore, soil classification is an important tool used by scientists to determine whether a site can be defined as a "wetland," deserving stricter regulations and protected status.

5. Hand out a copy of *Wetland Soils* to each student. Read and discuss the information about how organic debris, moisture content, and mineral composition influence the color of soils. Be sure that students understand these are general guidelines and that there is variance in classifying soils. Ask students to predict whether deeper soils are gleyed or mottled? Ask how they might detect whether the location of a sample was historically used as a sediment-dump site?

6. Divide students into groups. Distribute copies of the *Wetland Soil Color Chart* to each group and review the directions at the top of the page. Explain that this is a simplified version of a chart used by wetland scientists. Have students complete the *Wetland Soils Color Chart* in their groups.

7. **If taking a field trip to the wetland**, have student groups collect the soil samples and compare them against the *Wetland Soils Color Chart.* Tell students to break open the samples to check for the truest color. While in the field, have students complete the *Field Based Soil Sample Data Chart.* Have students share and combine their data to create and label a vertical diagram of the soil colors.

8. In the classroom, point out to students the various stations set up with soil samples. Hand out copies of the *Analyzing Soil Samples Worksheet* to each student group. Explain that at each station, they are to fill out a worksheet for each soil sample.

9. Have groups move from station to station until all groups have visited each station.

Follow-up:

Discuss the results of students' worksheets. Point out the following:

- In addition to color, a soil's texture and degree of wetness, along with other qualities like smell and the presence or absence of living matter (biotic or abiotic), provide clues to its classification.

- A rotten-egg smell indicates the presence of hydrogen sulfide, a product of anaerobic bacteria.

- Various layers of soil from the same hole may exhibit striking differences in color, texture, and smell, caused by the presence of water, the parent soil material, aerobic or anaerobic conditions, and so on. Vertical soil samples (cores) may provide insight to historical disturbance and climatic conditions.

Extensions:

Create a soil log to compare changes over time:

1. Use crayons to color a strip diagram that matches the horizons of the soil sample at each depth. Record the date the soil sample was collected and where it was collected. Has there been a change in the depth of the soil horizons since the previous year? Is the soil more or less hydric?

2. Using soil test kits, record the pH and nutrients present in the soil.
   Determine the acidity of each two-inch section of the soil sample. Soils with high organic matter tend to be more acidic, but fewer plants are adapted to acidic soil conditions. Does the pH change from the surface to the bottom section?
   Determine the nutrients available to wetland plants by testing for nitrogen, phosphorous, and potassium across depth and location. What might be the source of excess nutrients?

3. Our understanding of wetlands is evolving based on knowledge gained from data over time. Compare soil sample data from previous years at the same location to determine if changes have occurred.

Adapted from "Wetland Soils in Living Color" from
Project WET Curriculum and Activity Guide,

Wetland Soils

Wetland soils might be:

- saturated by permanent flooding,
- seasonally flooded, or
- intermittently covered to a shallow depth with water.

Wetland soil remains wet long enough that the upper soil layers are deprived of oxygen (anaerobic). Over time, this lack of oxygen produces chemical reactions that change the soil's color, as well as other characteristics, such as texture and organic content.

Even when water is not present, the color of soil can be used to identify an area as a wetland. By reading soils, scientists can derive information about the duration and frequency of wet conditions.

Wetland soils are divided into two major types:

1. organic
2. mineral.

Organic soils look like black muck or dark brown or black peat. Decomposing plants and animals contribute to the color of organic soils. In water-logged environments, which are anaerobic, organic materials tend to accumulate rather than break down (as they would in aerated environments).

Mineral soils lack organic material and are usually found deeper under the surface. Common mineral soil components are:

- sand
- silt
- clay

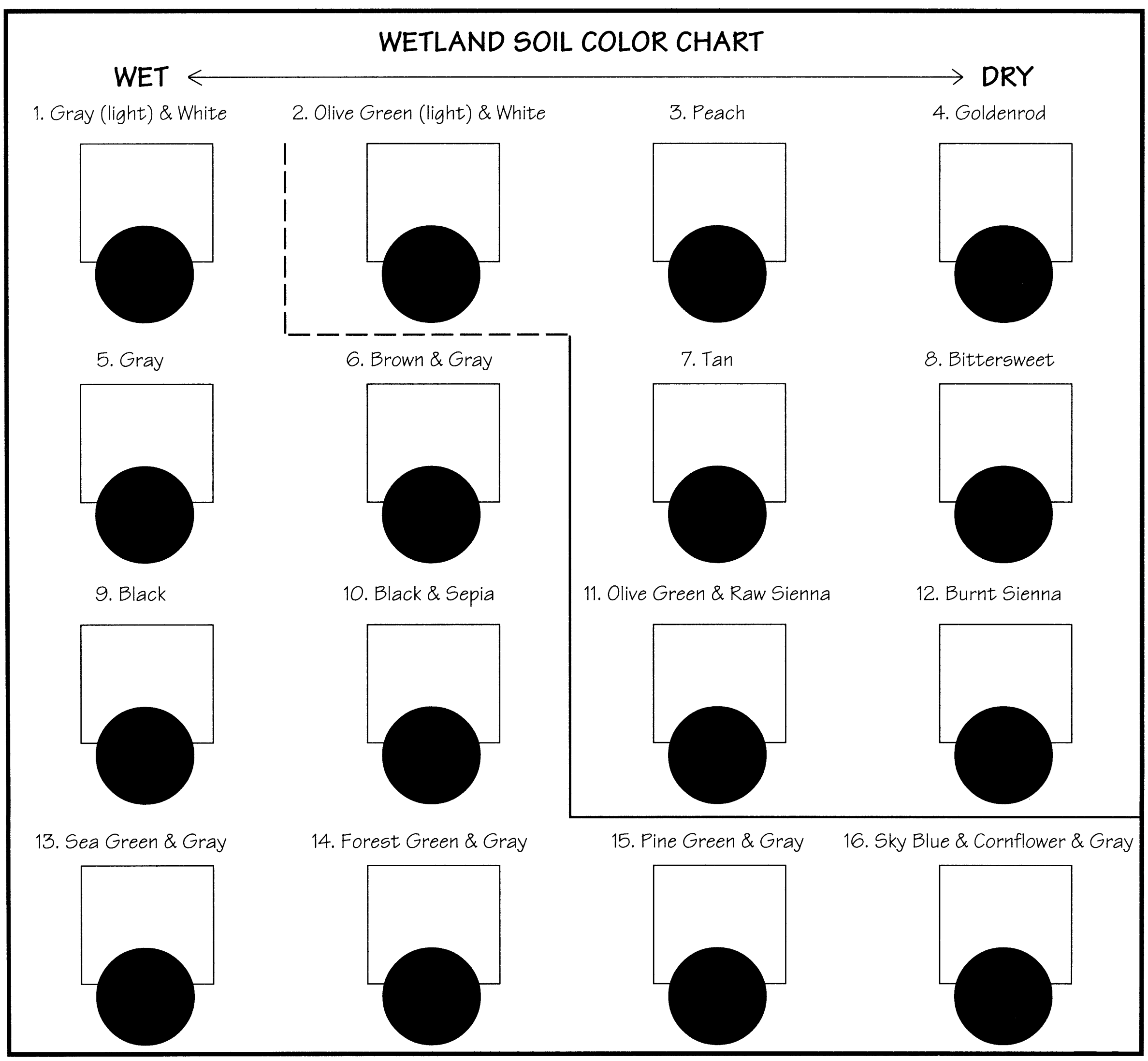
Mineral wetland soils can be gleyed (pronounced "glade") or mottled. **Gleyed** soils are created in anoxic environments where oxygen is removed from soil chemicals. The colors produced range from gray and bluish-gray to black, depending on the degree of saturation. **Mottled** soils are gray with splotches of brown, orange, red, or yellow, as a result of being alternately wet and dry. When oxygen mixes with iron, manganese, water, and other components in soil, a process similar to that which causes rust on garden tools or wrought iron occurs—oxidation—creating splotches of color. The same chemical processes are used in making pottery. When pottery is placed in a reduced (low oxygen) kiln, dark, muted colors result. When pottery is made with an oxidized firing, the finished colors are usually bright.

Wetland Soils Color Chart

Use crayons to color the squares on the chart below. Using the correct colors is very important! Press firmly when coloring unless the name says "light." Cut out the whole chart and paste it to a piece of poster board or card stock. Carefully cut out the black circles through all thicknesses.

Use this color chart when studying soil. Wetland professionals use similar color charts to help them identify wetland soils. Hold the chart in one hand; in the other hand, hold a sample of soil behind the chart so that it is visible through one of the holes. Move the sample around until you find a color that nearly matches the **main** color of the soil. Record this classification on the worksheet.

- Numbers 1, 5, 6, 9, 10, 13, 14, 15, 16, and sometimes 2 are probably wetland soils.
- Numbers 3, 4, 7, 8, 11, and 12 are probably not wetland soil.
- Numbers 14-16 are *gleyed* wetland soils and are most likely made of clay.
- Numbers 4, 8, and 12 can be used to match *mottles* ("rust spots") that may be found in wetland soil.



Field Based Soil Sample Data Chart

Student name(s): ______________________________ Date: ______________

Description of location: ______________________________

____

Description of plants present: ______________________________

____

Possible evidence of animals (burrows, insects, human artifacts—of value or trash): ______________

____

____

Possible sources of water: ______________________________

____

____

DEPTH OF SOIL SAMPLE	SOIL SAMPLE COLOR CLASSIFICATION	DAMPNESS OF SOIL SAMPLE (Does it stick in a ball? Can water be squeezed out?)	SOIL SAMPLE TEXTURE (Is it like coarse sand, fine silt, or clay?)

Analyzing Soil Samples Worksheet

Location of sample: ______________________

Depth of sample:______________________

Color Classification: ______________________

Describe the texture of the soil. *(Sandy soils feel gritty; silt will be smoother; and clay soils will form a ribbon when rolled. Place a one-inch ball of soil between thumb and base of forefinger. Gently push the soil with thumb, rolling it upward into a ribbon. If the ribbon forms longer than an inch, there is a lot of clay in the soil.)*

Are any organisms present? Describe, draw, and, if possible, identify the organisms.

What does the sample smell like?

Is the soil organic or mineral? Gleyed or mottled? What evidence helped you decide?

How does the soil at this depth differ from soils at different depths from the same location? What might account for the variation?

Do results confirm this area as a wetland?

Activity: Measuring Decomposition

Summary: Students will determine soil moisture content and then measure CO_2 production by using a titration to determine the decomposition rates in soil.

California State Content Standards

SCIENCE

Chemistry

- **Conservation of Matter and Stoichiometry 3a.** Students know how to describe chemical reactions by writing balanced equations.
- **Conservation of Matter and Stoichiometry 3e.** Students know how to calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic masses.
- **Acids and Bases 5a.** Students know the observable properties of acids, bases, and salt solutions.
- **Acids and Bases 5d.** Students know how to use the pH scale to characterize acid and base solutions.
- **Solutions 6d.** Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.
- **Reaction Rates 8a.** Students know the rate of reaction is the decrease in concentration of reactants or the increase in concentration of products with time.
- **Reaction Rates 8b.** Students know how reaction rates depend on such factors as concentration, temperature, and pressure.
- **Reaction Rates 8c.** Students know the role a catalyst plays in increasing the reaction rate.

Biology/Life Sciences

- **Ecology 6d.** Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.
- **Ecology 6e.** Students know a vital part of an ecosystem is the stability of its producers and decomposers.

Investigation and Experimentation

- **1a.** Students will select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- **1g.** Students will recognize the usefulness and limitations of models and theories as scientific representations of reality.
- **1j.** Students will recognize the issues of statistical variability and the need for controlled tests.

MATHEMATICS

- **Algebra I 3.0.** Students solve equations and inequalities involving absolute values.
- **Algebra I 15.0.** Students apply algebraic techniques to solve rate problems, work problems, and percent mixture problems.

Objectives:

Students will be able to:

- Perform a titration
- Measure decomposition rates in soil
- Explain the importance of decomposition
- Compare soil productivity by depth and habitat

Materials:

- Soil samples from Upper Newport Bay or other wetland (~100 g [~ 1/2-1 cup] for each titration, depending on moisture content)
- Drying oven or microwave
- Metric balance with 0.1 g accuracy
- Beakers
- Spoon or scoop for handling soil
- Distilled water
- Gloves and goggles
- *(optional)* Incubator
  (You can build an incubator using a light or heating pad in a box.)
- *(optional)* Magnetic stirring plate and bar
- Handouts
  - *Procedures for Determining Soil Moisture Content*
  - *Procedures for Measuring Decomposition Using a Titration*
  - Data Form 1: *Soil Moisture Content*
  - Data Form 2: *Measuring Decomposition Using a Titration*
  - Data Form 3: *Summary*

For collecting samples:

Lid to a wide-mouthed container
Knife
Garden trowel and spatula
Plastic wrap
Marker
Air-tight container

For each soil sample:

- 1 shallow, wide, *airtight* container (approximately 25 cm x 25 cm)
- Beaker to hold NaOH (needs to fit inside the airtight container with air space above)
- 20 mL 1M NaOH *(sodium hydroxide)*
- 10 or 20 mL pipette
- 20 mL 1M HCl *(hydrocloric acid)*
- 2 mL 1M $SrCl_2$ *(strontium chloride)*
- Phenolphthalein
- 20-50 mL buret or "Poor Man's Buret"

Note: For every 5 soil samples, you will need to create a "blank," which will require an additional airtight container and beaker with NaOH.

Note: The activity "Wetland Soil" also requires soil samples. Consider collecting samples for both activities concurrently.

Preparations:

- Obtain soil samples from Upper Newport Bay or other wetland location (see Appendix D). Check with wetland staff to verify that samples can be taken.

  - Take samples from various areas (mudflat, salt marsh, riparian, upland) and various depths (e.g., a shallow sample at one to three inches and a deeper sample at four to six inches). A recommended sampling might be:

mudflat	—	shallow	1
		deep	1
salt marsh	—	shallow	1
		deep	1
riparian	—	shallow	1
		deep	1
restored upland	—	shallow	1
		deep	1
invaded upland	—	shallow	1
		deep	1
		Total Samples	10

To take a sample:

Important: Keep the soil as intact as possible because microbial activity in the soil is dependent on soil structure.

1. Brush away any undecomposed litter layer.
2. Lay the lid of a wide-mouthed jar (e.g., peanut butter jar) or similar object on the soil.
3. Use a knife to cut out a "cookie" of organic soil around the lid, cutting as deep in the soil as you need, and carefully use a trowel or a spatula to lift the sample out. Alternatively, use a soil corer.
4. Wrap each sample in plastic wrap and label its location, depth, and the date it was collected.
5. Place samples in an airtight container with minimal disturbance.

- Make copies for each group of:
  - *Procedures for Determining Soil Moisture Content*
  - *Procedures for Measuring Decomposition Using a Titration*
  - Data Form 1: *Soil Moisture Content*
  - Data Form 2: *Measuring Decomposition Using a Titration*
  - Data Form 3: *Summary*

Time Required:

- To obtain soil samples:
  - approximately 1.5 hours

- To determine soil moisture content:
  - approximately 25 minutes
  - if soil is too wet, additional time to dry soil sample
  - if soil is too dry, an additional 15 minutes and then 24 hours to rest soil

- To perform titration:
  - approximately 15 minutes to prepare soil samples
  - 24-48 hours to incubate
  - approximately 30 minutes to titrate
  - approximately 15 minutes for follow-up

Procedures:

1. Introduce the lesson to students by conveying the following information:

   Soil consists of both inorganic and organic material. The inorganic material comes from rocks that have broken down to smaller particles. The organic material comes from living things in the soil. For example, plants shed leaves and drop twigs onto the soil. Eventually, this litter layer decomposes and becomes part of the organic material in the soil. When plant roots die, they also become part of the organic material in the soil. Additional organic material is added when invertebrates that live in the soil, such as worms, die. Finally, many different organisms add organic matter to the soil in the form of feces and other waste products.

   When microbes and invertebrates break down organic matter in soil, they produce CO_2 through the process of respiration. Thus, the rate at which CO_2 is produced in soil is a good indicator of the rate of decomposition of organic matter in the soil.

2. Tell students that they are going to be testing soil samples from Upper Newport Bay (or other location) to determine the rate of decomposition in the soil. Explain that they will measure the CO_2 produced by microbes and invertebrates in a *microcosm*—a small scale laboratory model of what occurs in nature.

3. Before students perform each procedure, have them hypothesize results.

Determine Soil Moisture Content

4. Explain that to measure decomposition in soils, they need to measure soil moisture content because:
   - it allows calculation of the dry weight of the sample, a number that is used in the formula for determining the rate of CO_2 production;
   - the moisture greatly affects the rate of activity of soil microbes.

5. Divide students into groups according to the number of soil samples and assign a sample to each group. (For example, if you have collected 10 soil samples and have a class of 30, divide students into 10 groups of 3 students each.)

6. Hand out to each group a copy of Data Form 1: *Soil Moisture Content* and have each group fill in the top of the form.

7. Hand out a copy of the *Procedures for Determining Soil Moisture Content* to each group. Have students follow the procedures and fill in their data forms as they work.

Measure Decomposition Using a Titration

8. Tell students that they will be using the reaction of CO_2 with sodium hydroxide (NaOH) to measure the amount of CO_2 released from the soil. Explain that CO_2 produced by the microbes and invertebrates in soil reacts with NaOH as shown in the following equation:

$$2\ NaOH + CO_2 \rightarrow 2H^+ + CO_3^{2-} + 2\ Na^+ + O^{2-}$$

9. Overview the titration procedure:

   Begin with a known quantity of NaOH in a beaker placed in your soil microcosm—in this case, an airtight container. Because the CO_2 respired by soil microbes reacts with NaOH to form carbonic acid (H_2CO_3), the beaker solution becomes more acidic over time, as it absorbs CO_2.

   Next, add strontium chloride ($SrCl_2$) to the solution. $SrCl_2$ reacts with CO_3^{2-} to form an insoluble precipitate. This removes all CO_3^{2-} from solution and prevents the equation equilibrium from moving back to the left.

   Next add phenolphthalein to the solution. Phenolphthalein is pink in basic solutions and clear in solutions that are neutral. When you first add phenolphthalein to your solution, the presence of basic NaOH will cause the solution to turn pink.

   Then you will titrate—that is, add known quantities of acidic HCl into the solution. When the solution develops a neutral pH, it will turn clear. By measuring how much acid must be added to make the solution neutral, you can find out how much CO_2 was absorbed through microbial action during the incubation period. Solutions requiring less HCl indicate more productive soils. You will need to use "blanks" to account for background levels of CO_2.

10. Hand out the *Procedures for Measuring Decomposition Using a Titration* to each group. Point out there are three parts to this activity—preparing blanks to account for background levels of CO_2, preparing soil samples, and titrating. Explain that one blank needs to be prepared for every five soil samples. If each group is doing fewer than five samples, determine which groups will prepare the blanks.

11. Hand out to each group Data Form 2: *Measuring Decomposition Using a Titration.* Have students follow the procedures for performing a titration and fill in their data forms as they work.

Follow-up:

1. When students have finished the procedure, use Data Form 3: *Summary* to compare and discuss the results.

2. Use the following questions to discuss or have students write about their experiment.

   - Describe the general results of the titration experiment. What did you learn about soil CO_2 production rates?

   - Were CO_2 production levels higher or lower than you expected? Explain.

   - If you had replicates for each soil type, what was the average for each soil type? What does the average tell you about differences between soil types?

   - Did you see any variability among soil samples in the same soil type? What might be some reasons for the variability?

   - Why is the measurement of soil decomposition rates useful or important?

Extensions:

1. Collaborate with another school that has performed this experiment to compare results.

2. Test your backyard soils and compare results.

Adapted from *Invasion Ecology* from NSTA Press.

Procedures for Determining Soil Moisture Content

1. Mix the entire soil sample thoroughly and remove any large chunks, such as pebbles or roots.

2. Record the weight of a small beaker.

3. Put a subsample of the soil—10-20 g—into the beaker. Weigh the soil and the beaker.

4. Subtract out the weight of the beaker to determine the weight of the subsample. (This is the *wet weight*.)

   Wet wt of soil = combined wt of beaker and soil - wt of beaker

5. Dry the soil using either a drying oven or microwave. If using a drying oven, dry the sample for 24 hours at ~100°C. If using a microwave oven, first heat the sample on low power for 5 minutes, allow to cool, and then weigh it. (It is essential to use low power so that the soil does not reach a high enough temperature to burn or release anything other than water.) Continue heating for one additional minute and weigh the sample at each interval. Repeat this cycle until the weight change before and after heating is minimal.

6. After drying the soil, record the weight of the beaker and the soil. Subtract out the weight of the beaker to determine the weight of the soil (This is the *dry weight*.)

   Dry wt of soil = combined wt of beaker and soil after drying - wt of beaker

7. Calculate the moisture content using the following equation:

$$\textbf{Moisture content} = \frac{\textbf{wet weight - dry weight}}{\textbf{wet weight}}$$

   This result is expressed in decimal form for use in dry weight and CO_2 calculations. To express as a percentage instead, simply multiply by 100.

8. **If the soil is in the 10-90% moisture range**, proceed to titrating.

9. **If the soil contains more than 90% water,** it is too wet. Spread out the total soil sample (from which your subsample came) in a thin layer and allow it to dry at room temperature out of direct sunlight until it looks moist but not wet. Repeat steps 3-7 with a new subsample after the soil has dried, to determine if the desired % moisture has been reached. If the soil is still too wet, continue the drying process until the moisture content is near 50%.

10. **If the soil contains less than 10% moisture**, follow these steps:

A. Weigh the total soil sample (from which your subsample came). This is the *total soil weight*.

B. Calculate the actual water weight in your total sample using the moisture content you previously determined using this formula:

Actual water wt of full sample = total soil wt of full sample x moisture content of subsample

C. Find the total dry weight of your soil sample.

Dry wt of full sample = total wt of full sample - actual water wt of full sample

D. For a 50% moisture sample, the *desired water weight* is equal to the dry weight of the sample. Determine how much water you need to add by using this calculation:

Wt of water to be added = desired water wt - actual water wt

To weigh water, first weigh a beaker and then slowly add water until you have the correct weight (correct weight = [beaker + water] - beaker).

E. Add the amount of water needed by gently sprinkling the water into the entire soil sample and mixing thoroughly. Use only distilled water.

F. Let the soil sit for 24 hours to allow microorganisms to regain activity before titrating.

Procedures for Measuring Decomposition Using a Titration

Part 1: Preparing Blanks

1. Create one blank for every five soil subsamples. Follow steps 3-7 of the Preparing Soil Samples procedure (Part 2) and steps 1-7 of the Titrating procedure (Part 3) **except** do not use any soil. This will allow you to compensate for any background CO_2 that was not contributed by the soil microbes.

2. Leave the blanks with the other containers and run titrations on all samples and blanks at the same time.

Part 2: Preparing Soil Samples

1. Weigh the bottom of the airtight container to the nearest 0.1 g.

2. Mix soil sample thoroughly and then transfer ~25 g into the airtight container. Record the total weight of the bottom of the container and soil sample combined, to the nearest 0.1 grams.

3. Using a pipette, transfer 20 mL of 1M NaOH solution into a beaker.

4. Place the beaker containing NaOH into the airtight container with soil. The container must be tall enough to allow airspace above the NaOH beaker when the container is sealed. Be careful not to spill any NaOH.

5. Tightly seal the airtight container. Record the date, time, and temperature.

6. Store airtight containers with soil and NaOH at room temperature (20-30°C) or warmer if possible. Provide a constant warm temperature. A sunny windowsill is not appropriate because it will get hot during the day and cold at night. An incubator set at 37°C is ideal.

7. Allow the soil samples to incubate for 24-48 hours.

Part 3: Titrating

1. Record the date and time the incubation ended.

2. Open the airtight container only when you are ready to titrate. Add 2 mL of 1M $SrCl_2$ to the NaOH solution. A white precipitate should form.

3. Add 2-3 drops of phenolphthalein indicator to the NaOH solution. The phenolphthalein should cause the solution to turn pink.

4. Fill the buret with 1M HCl and zero it. Titrate very slowly with the acid until the NaOH solution begins to become clear. Frequently swirl or use the magnetic stirrer to mix the solution while adding acid.

5. As the endpoint gets closer, add HCl one drop at a time, mixing thoroughly between drops. The endpoint has been reached when the solution turns from pink to clear. The greater the amount of CO_2 that has been released from the soil and has reacted with the solution, the less acid it will take to reach the titration endpoint.

6. Record the molarity of HCl used (should be 1M) and the volume of HCl required to reach the endpoint (clear solution).

7. Calculate your results using Data Form 2: *Measuring Decomposition Using a Titration*.

Data Form 1: Soil Moisture Content

Names of group members: ______________________________

Date: ______________________________

Soil sample ID number: ______________________________

Soil sample location: ______________________________

Soil sample depth: ______________________________

Date sample was collected: ______________________________

The steps below correspond to the procedural steps on the handout "Procedures for Determining Soil Moisture Content."

Step 1: Describe the soil sample (e.g., number and size of rocks and roots in sample; color; wet or dry to the touch):

Step 2: Weight of beaker = __________ g

Step 3: Weight of beaker and soil = __________ g

Step 4: Wet weight of soil

__________	-	__________	=	__________ g
combined wt of beaker and soil		weight of beaker		Wet weight of soil

Step 5: Drying time in drying oven: ______________________________

OR

Time and power level in microwave: ______________________________

Step 6: Dry weight of soil

__________	-	__________	=	__________ g
combined wt of beaker and soil after drying		weight of beaker		Dry weight of soil

Step 7: Moisture content

$$\textbf{Moisture content} = \frac{\textbf{wet wt - dry wt}}{\textbf{wet wt}} = \frac{\_\_\_\,\textbf{g} - \_\_\_\,\textbf{g}}{\_\_\_\,\textbf{g}} = \_\_\_\_\_\_\_\_$$

x 100 = __________%

<u>Step 8</u>: If soil is in the 10-90% moisture range, proceed to titrating.

<u>Step 9:</u> If soil contains more than 90% water, continue drying process until moisture content is near 50%.

<u>Step 10</u>: If soil contains less than 10% moisture:

A. Total soil weight = __________ g

B. Actual water weight of full sample

__________	x	__________	=	__________ g
total soil wt of full sample		moisture content of subsample		actual water wt of full sample

C. Dry weight of full sample

__________	-	__________	=	__________ g
total soil wt of full sample		actual water wt of full sample		dry wt of full sample

D. Weight of water to be added

__________	-	__________	=	__________ g
desired water wt		actual water wt		wt of water to be added

Data Form 2: Measuring Decomposition Using Titration

Names of group members: ______________________

Date: ______________________________________

Soil sample ID number: ________________________

Soil sample location: __________________________

Soil sample depth: ____________________________

Date sample was collected: _____________________

1. Calculate dry weight of soil.

Weight of container (without lid)	=	__________ g
Weight of container with soil	=	__________ g
Total Soil Weight	**=**	__________ **g**

Use Total Soil Weight and % soil moisture (Step 7 of Determining Soil Moisture Content) to calculate dry weight of soil. Remember to use the fraction for moisture content, not the percentage.

__________ g	-	__________	=	__________ g
total soil wt		(moisture content x total soil wt)		dry weight

This answer will be in grams of dry soil. For use in the final equation, you need to convert it to kilograms:

__________ g	x	0.001 kg/g	=	_________ kg dry soil
dry weight				

2. Record the amount of time you used for the incubation.

Date and time incubation began: ____

Date and time incubation ended (should be 24-48 hours): ______________________________

Length of incubation period = __________ days

(e.g., 27 hours = 1.125 days)

3. Calculate the CO_2 produced by soil samples and the amount present in the blank(s).

Molarity of HCl used in titration ____________________
(This should be 1. If different, ask your teacher for help in altering the final CO_2 respiration equation.)

Milliliters HCl used to titrate sample ____________________

Milliliters HCl used to titrate blank ____________________
(If you used more than one blank, determine the average.)

CO_2 produced:

(________mL	-	________mL)	x	22*	=	__________ mg
HCl used to titrate blank		HCl used to titrate sample				**CO_2 produced**

4. Calculate the CO_2 production rate.

The CO_2 production rate is the rate of CO_2 produced in milligrams CO_2 per day per kilogram of dry soil. Use the kg dry soil from step 1, number of days incubation from step 2, and mg CO_2 from step 3 above.

$$CO_2 \text{ production rate} = \frac{[(CO_2 \text{ produced in milligrams})/(\text{\# of days incubated})]}{(\text{kilograms dry soil})}$$

= __________ (mg CO_2/day) / kg dry soil

* You may wonder why there is a "22" in the equation. It is necessary to convert from milliliters HCl into milligrams CO_2 as shown in the following equation:

$$(HCl_{blank} - HCl_{sample}) \times 22 = (HCl_{blank} - HCl_{sample}) \times \frac{1 \text{ liter}}{1000 \text{ mL}} \times \frac{1 \text{ mol HCl}}{\text{liter}} \times \frac{44 \text{ g } CO_2}{\text{mol } CO_2} \times \frac{1 \text{ mol } CO_2}{2 \text{ mol HCl}} \times \frac{1000 \text{ mg}}{\text{g}}$$

HUMAN IMPACTS

As more and more people populate the Earth and as more and more land is taken over by humans, many natural areas—including wetlands—are destroyed, degraded, or reduced in size. Human activities have also brought water pollution and invasive species that threaten our remaining wetlands.

Loss of Wetlands

The United States has lost approximately one half of the wetland area that existed before European settlers arrived. In California, the percentage lost is even higher, much higher—91 percent. In 2000, only 400,000 acres of the state's original three to five million acres of wetland area remained. In Orange County, accelerated development destroys more than two square miles each year.

Where Have All the Wetlands Gone?

Historically, the largest losses in wetland acreage around the world have been due to agriculture. Drained wetlands often produce fertile farmland, at least for a while. In the U.S., over 80 percent of wetland loss can be attributed to agriculture.

Now, however, it is not agriculture but urban and suburban growth that is destroying wetlands. Coastal wetlands are the most endangered. People want to live and work near the water, and industries prefer to be located near discharge points or cooling water sources supplied by the ocean. So, coastal property has high real estate value. Estuaries have been turned into harbors, amusement parks, nuclear power plants, university campuses, airports, and housing tracts. Even when wetlands are preserved, chemical and biological pollution from nearby development can disrupt the delicate balance of wetland ecosystems.

Why Does It Matter?

When we lose wetlands, we lose the benefits that wetlands provide, such as filtering pollutants from runoff, supplying habitat for wildlife and providing recreational areas for people. The loss of wetlands also results in the loss of biodiversity.

Biodiversity refers to the variety of plant and animal species coexisting within an ecosystem. Ecologists know that the more kinds of organisms that can coexist in a system, the more stable or resilient that system is. The loss of wetlands has endangered many species of plants, birds, fish, and other wildlife that depend on associated habitats for food, shelter, and breeding. In southern California, endangered animals that depend on coastal sage scrub include: California Gnatcatcher, Sage Sparrow, little pocket mouse, San Diego horned lizard, and the orange-throated whiptail lizard. About one-half of the 188 animals that are federally designated as endangered or threatened are wetland dependent.

Even if development does not completely destroy a wetland, it can break the wetland up into smaller chunks—a problem called fragmentation. By reducing the quantity or quality of habitat available, fragmentation lowers the diversity of plants and animals. Species that are very rare or that are found only in small populations are especially at risk when habitat portions are destroyed. And if another species depends on the lost species for either food or shelter, it too might be lost, disrupting the food web and its connection to the entire ecosystem.

Many habitat fragments are surrounded by barriers—roads, parking lots, buildings—that prevent species from moving between different areas to get what they might need to survive, such as food, shelter, and mates. When a species is isolated from others of its kind, it can become subject to inbreeding and lose some of its genetic diversity. Gene pools are like a bag of survival tricks. A species with less genetic diversity is less likely to survive disturbances such as flooding or grazing.

The loss, degradation, and fragmentation of habitats are important factors behind species endangerment and extinction.

Urban Encroachment

As our cities grow larger with more people and more development to accommodate these people, even wetlands with protected status are affected.

Loss of Buffers

A wetland ecosystem includes both land that is actually "wet" and surrounding areas called buffer zones. These buffer zones are areas where some species retreat during high tide and where pollutants and sediments can be filtered before entering the water. Buffer zones also absorb such impacts as noise and pet disturbance. But as people move closer and closer to wetlands, the buffer zones are lost.

Upper Newport Bay's historical buffer zone was composed of grasslands and coastal sage scrub. Much of this habitat has been degraded or converted. The coastal sage scrub adjacent to the wetlands has been used in the past for livestock grazing and as a dump for sediment dredged out of the Bay, both of which compacted the soils and altered their chemistry. The resulting degraded habitat is prone to invasion by non-native plants, which now dominate the area. Bluffs surrounding the Bay have been converted to housing developments. Much of the landscaping for these houses provides seed stock for more non-native plant invasions, a true form of biological pollution. Non-native landscaping often requires irrigation, which creates run-off with fertilizers and pesticides that flow directly into the Bay.

Coastal sage scrub, an integral component of Upper Newport Bay's ecosystem, is now an endangered ecological community. It is estimated that only ten percent of California's historic coastal sage scrub acreage remains, and most of this land is in private ownership. Less than ten percent of the remaining habitat is formally protected; the rest may be slated for development.

People and Their Pets

As development moves closer to wetlands, so do the people. Wetlands provide wonderful recreational opportunities, but with more and more people come more and more potential threats.

At Upper Newport Bay, thousands of people jog, bicycle, kayak, or walk through the Bay each year. Unfortunately, many of these people leave trash behind, trample wildlife, and cause erosion by making their own trails. It's not only people but also their pets that can cause damage to this ecosystem. Horse and bike traffic can erode trails, and unleashed dogs disturb bird nests, especially those of the Light-footed Clapper Rail, an endangered species that builds its nests among the grasses in the marsh. Also, pet waste that washes into the Bay can result in water pollution.

Too Much Dirt

Even development far from the wetland can cause problems. Rain washes soil eroded from construction sites and farm fields through the watershed, ultimately depositing these sediments into the wetland. Increased urbanization in the Upper Newport Bay watershed has resulted in the need to form concrete channels in San Diego Creek that direct storm water and dry-weather runoff quickly, and with more silt, into the Bay. Such channelization is common practice in areas that have developments on floodplains.

Excessive amounts of silt in a wetland can clog the gills of fish, bury their eggs, obliterate underwater shelters, and cloud the water so little sunlight can reach aquatic plants, which depend on the light for photosynthesis. In Upper Newport Bay, nearly a million cubic yards (approximately the volume of 19 Olympic-sized pools, or a million pick-up truckloads) of sediments were dredged from the northeast corner of the Bay in 1998-99. More than twice that amount is slated for removal in 2004-2005, and similar dredge operations are expected every 21 years. Without dredging, the Newport Harbor would eventually become inaccessible by boat.

Water Quality

While it is true that wetlands can reduce or eliminate the harmful effects of water pollution, they can also become overwhelmed if the amount of pollution exceeds that wetland's biological capacity. Large quantities of pollutants washed into wetlands can lead to the death of plants, animals, and important microorganisms.

There's No Point to Pollution

Pollution comes from many sources. *Point* source pollution is discharged from, and can be traced back to, an identifiable point or source, such as a factory's discharge pipe. But most pollution entering wetlands is *nonpoint* source pollution. Nonpoint source pollution is contaminated runoff that originates from an indefinite or unidentifiable place; usually it accumulates from a variety of places.

As the drain for the watershed basin, a coastal wetland ends up with whatever finds its way into the flowing water. In Upper Newport Bay, that includes:

- **Trash** — Foamed plastic cups, paper, cans, bottles, plastic bags and packages, cigarette butts, and other garbage all can be found in the Bay, whether washed in through storm drains or carelessly dropped by visitors. Not only is the trash unsightly, it is also dangerous to the marine life and the birds that get tangled up in it or eat bits of plastic, mistaking it for food.
- **Chemicals** — We use toxic chemicals every day, and many of them end up on the ground where they can get washed into rivers or storm drains. Pesticides, paint, cleaners, polishes, glue, oil, gasoline, and auto-coolant are all helpful to us but harmful to the Bay ecosystem. Oil and grease can coat bird feathers; other toxic chemicals can kill or contaminate fish and plant life.
- **Metals** — Metallic substances can leach from paints applied to the bottoms of boats moored in the lower bay. Fine metallic particles from car brake pads accumulate as dust along the sides of roads and get washed down to the Bay with run-off. These metals can accumulate in animal tissues.

- **Fertilizers and animal waste** — Commercial nurseries, golf courses, hotels, and homes all use fertilizers. These fertilizers, along with waste from animals—dogs, horses, and wildlife—get picked up by runoff and then deposited in the Bay. Fertilizers and animal waste are actually nutrients, which promote plant growth. But an excess of these nutrients in the Bay can cause algae blooms—the overgrowth of algae. When the algae die, the oxygen in the water is used up by microbes through decomposition, which affects all living things in the water. This process, called eutrophication, can cause fish to die from lack of oxygen. Eutrophication is also responsible for the sulphuric smell rising from the Bay—a sign of anaerobic decomposition.
- **Green waste** — Grass clippings, tree branches, leaves, dead plants—all can end up in the Bay. In 2004, the County of Orange found that 99 percent of trash intercepted by street sweepers was organic debris. Like fertilizers and animal waste, green waste can dramatically increase the nutrient levels in the Bay, resulting in eutrophication.

Non-native Species

Non-native, invasive plant and animal species are another major threat to wetlands across the country.

Who's Native?

Native plants (also called indigenous plants) are plants that have evolved over thousands of years in a particular area. California has the largest number of native plant species of any state in the nation. A plant is native to California when its origins, for as long as can be traced back, are from California. Native species—such as California sagebrush and arroyo willow—have been here for so long they are specifically adapted to our climate, soils, and habitats.

Most native plants occur in communities; that is, they have evolved together with other plants. As a result, a community of native plants provides habitat for a set of native wildlife species, including pollinators and herbivores, which are specifically adapted to life in that community. They depend on one another for food, air, nesting, resting, and hiding places.

Alien Invaders

Non-native plants (also known as non-indigenous, introduced, or exotic) are species that have been introduced into an environment in which they did not evolve. Introduction of non-native plants into our landscape has been both accidental and deliberate.

In their new homes, non-natives generally have no enemies or controls—such as natural pests, herbivores, diseases, or parasites—to limit their growth. These invasive species out-compete native species for nutrients, water, sunlight, and living space. As they spread, the native plant communities are displaced, and often, along with them, the animals that depend on the plants for food or shelter. The functions of the entire ecosystem are disrupted.

When non-native species dominate native vegetation, they can:
- eliminate the native plants that provide food and shelter for wildlife
- degrade the variety and quality of habitats
- dramatically reduce biodiversity
- alter soil chemistry
- promote erosion
- sequester water
- alter fire-frequency.

In the Bay

Many California native plants live at Upper Newport Bay, including:
- bush sunflower
- California buckwheat
- California sagebrush
- pickleweed
- cordgrass

Some are endangered, such as the salt marsh bird's beak, which, once prevalent in coastal Orange County, can only now be found in Upper Newport Bay.

Invasive non-native plants have found their way into the Bay. Three that are commonly seen are ice plant, pampas grass, and giant reed. Giant reed is a particularly destructive invader. It can grow over two feet per week and colonizes quickly in the presence of freshwater, displacing native plants and wildlife because of the massive stands it forms. As it out-competes local vegetation for space and water, it reduces habitat and food supply for several species, particularly insect populations. Unlike native riparian plants, giant reed provides little shade, leading to increased water temperatures and reduced habitat quality for aquatic life. It also promotes bank erosion because of its shallow root system, contributing to more sediment being deposited in the Bay.

Activity: Changes Over Time

Summary: In this activity, students will compare aerial photographs of Upper Newport Bay taken in 1938, 1975, and 2001 to discover how the area has changed and what impact that change has had.

California State Content Standards

SCIENCE

Biology/Life Sciences

Ecology 6b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Earth Sciences

California Geology 9a. Students know the resources of major economic importance in California and their relation to California's geology.

California Geology 9c. Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

Investigation & Experimentation

1d. Students will formulate explanations by using logic and evidence.

1i. Students will analyze the locations, sequences, or time intervals that are characteristic of natural phenomena

Objectives:

Students will be able to:

- Interpret and compare aerial photographs
- Describe the changes in the area caused by human development
- Determine how development has possibly affected wildlife habitat and populations in Upper Newport Bay

Materials:

- *UNB Inhabitant Cards* (Appendix A)
- Handouts
  - Aerial photographs of Upper Newport Bay in 1938, 1975, and 2001
  - *Changes Over Time* worksheet

Preparation:

- Make a copy for each group of:
  each aerial photo
  Changes Over Time worksheet
  Newport Bay Timeline

Time Required:

Approximately 1 hour

Procedures:

1. Divide students into small groups and give each group a copy of the three aerial photos. Point out that the photos were taken of the Upper Newport Bay watershed in 1938, 1975, and 2001. Ask students to look at the photos for a few minutes and try to identify landmarks, such as Pacific Coast Highway, Shellmaker Island, the Salt Dike, and orange tree groves.

2. Hand out a copy of the *Changes Over Time* worksheet to each group. Tell students to look at the photos to determine what changes have occurred in each of the areas shown on the worksheet—that is:
   - Are there more or less?
   - Have there been alterations?
   - Has anything disappeared?

   Tell students to record the changes in the "Change" column of their worksheets.

3. Using the species included on the *UNB Inhabitant Cards*, or on the list of *Species Common to Upper Newport Bay* in Appendix B, ask students to consider how each change might affect wildlife in the Bay. Have students record their ideas in the "Possible Impacts on Wildlife" column on the worksheet. For example: "The increase in open water has greatly enlarged the feeding grounds for diving birds such as the Least Tern."

4. Bring the class together to compare their findings. Ask students to think about and discuss whether the wildlife in the Bay was generally better off in 1938, 1975, or 2001. Remind students that the Clean Water Act was passed in 1972, along with the ban of DDT and other toxic chemicals that polluted the wetland.

Follow-up:

Use the following questions to ask students what they learned from comparing the photos.

1. What anthropogenic (human-made) features have been harmful to wildlife in the Upper Newport Bay and why?

2. What do you think the Bay will look like in 50 years? Remember, global climate change data estimate that sea level will rise three millimeters each year—over three inches in 50 years.

3. Have students use the *Newport Bay Timeline* to relate historical events to changes observed in the aerials.

4. Use the California Coastal Records Website (*www.californiacoastline.org*) to look at historical aerials of California's coastline. By clicking on "Time Comparison," users can compare photographs from 2002 and 1972.

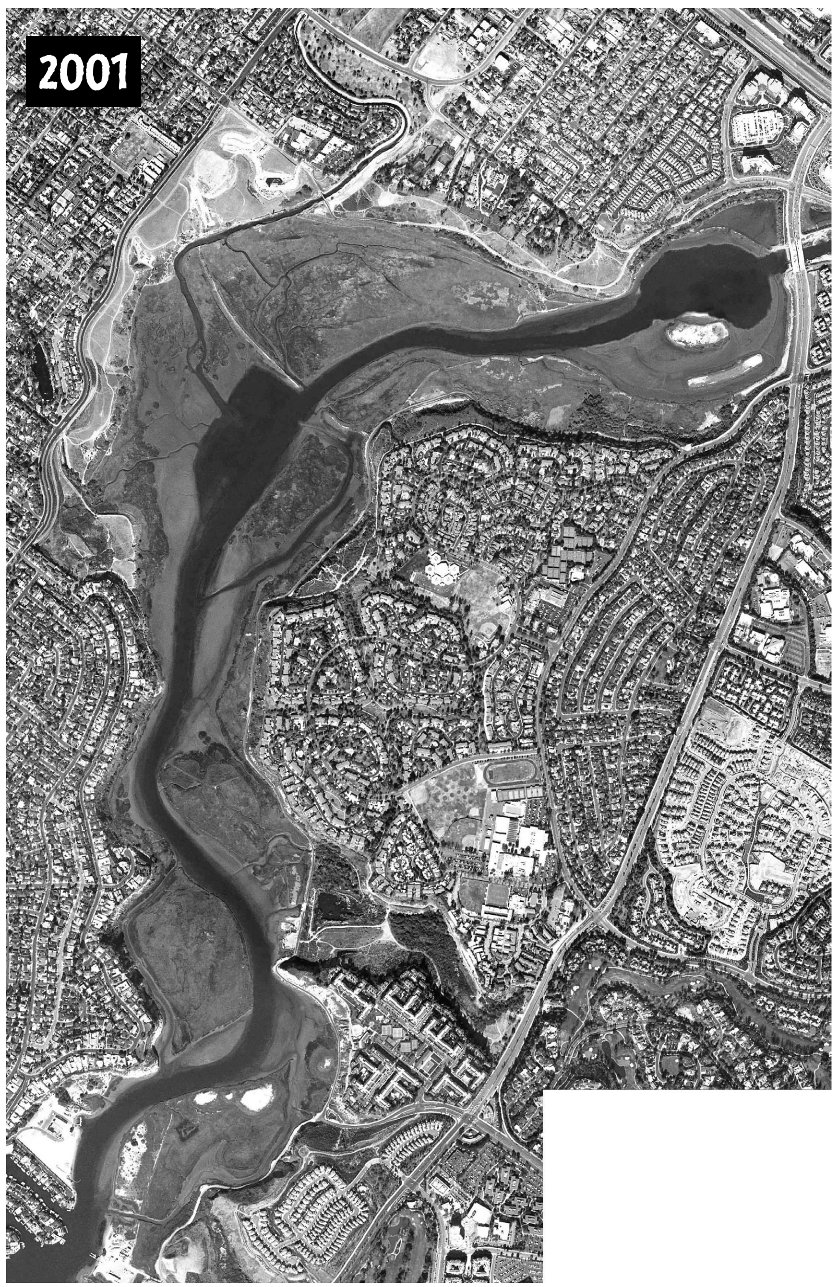
Changes Over Time

Area	Change	Possible Impacts on Wildlife
Open Water		
Rivers		
Wetlands		
Farms/Ranches		
Parks		
Shopping Centers		
Houses		
Businesses		
Streets, Roads, Sidewalks		
Parking Lots		
Other		

Newport Bay Timeline

(0-500s)- The Tongva (Gabrielinos) set up small villages in the Bay.
1700s- Spanish missionaries arrive and create agricultural communities.
1825- Floods cause Santa Ana River to empty into Newport Bay. Sand deposits build the basis for Balboa Peninsula.
1830s- Rancher Sepulveda is awarded a Mexican land grant for Rancho San Joaquin, including the shorelines of upper and lower Newport Bay.
1864- Sepulveda sells Rancho San Joaquin to James Irvine.
1888- American entrepreneur James McFadden builds ocean wharf extending from the peninsula to deeper waters so large vessels can safely dock. The area is called “New Port.”
1905- Pacific Electric Railroad connects Newport to Los Angeles. Waterfront hotels and beach cottages are built to accommodate tourists.
1920- As a protective measure against flooding, west jetty is built and Santa Ana River is redirected from the bay so that it empties directly into the ocean.
1922- Duke Kahanamoku hosts first World Surfing Championship in Newport, introducing the sport to the Western United States. First sanitary sewers are constructed.
1927- East jetty built and harbor entrance dredged.
1929- The Great Depression unfolds. Lido Island dredged and filled.
1932- Scientist Lawrence Booth begins documenting Orange County’s wetland plants, providing an invaluable resource for future restoration projects.
1934- Irvine Company builds dikes and basins to extract salts from the Bay through solar evaporation.

1935- Dredging harbor sandbars and extending jetties creates current-day layout of Newport Beach.
1938- Colossal storm hits Orange County, massive flooding leaves 119 dead and 2,000 homeless.
1945- WWII ends. Real estate market skyrockets as permanent homes are built in Newport.
1960s- The Bay is opened as a water-skiing area. City Council bans dogs on Balboa beaches.
1965- Developments such as UCI, Fashion Island, and an airport are built on top of wetland habitat.
1967- Friends of Newport Bay is established by a group of citizens, including Frank and Francis Robinson, to call attention to the ecological importance of the Bay.
1968- Flood control efforts initiate channelization of San Diego Creek, increasing drainage area into the Bay from 15 square miles to 154 square miles.
1969 - Heavy rains cause San Diego Creek to overflow, obliterating salt works, and washing tons of sediment into the Bay.
1969- Citizens file lawsuit against proposed property exchange between Irvine Company and County of Orange that would allow hotels and marinas along the shoreline.
1972- Clean Water Act established; restrictive height limit enforced to preserve coastal views.
1975- Community efforts pay off. State purchases land from the Irvine Company and receives a transfer of land from the County. The 140-acre Upper Newport Bay Ecological Reserve is dedicated to "the people of the State of California, so that this and future generations may continue to have, to use and enjoy the priceless heritage of the wildlife resources."
1996- El Nino floods trigger erosion and sedimentation of Big Canyon, destroying trails and bridges.
1998- Nearly a million cubic yards of sediment dredged from the northeast corner of the Bay.
2000- UC Irvine restores seasonal freshwater ponds for San Joaquin Freshwater Marsh.
2000- Peter & Mary Muth Interpretive Center, an environmental education facility, opens.
2002- 100 breeding pairs of Light-footed Clapper Rails exist in the Bay—the only place in the world where the Clapper Rails successfully breed.



Activity: Nonpoint Source Pollution

Summary: In this activity, students will read and interpret a map showing runoff drainage and how it affects Upper Newport Bay. Students will consider some solutions to the problem of nonpoint source pollution.

California State Content Standards

SCIENCE

Biology/Life Sciences
- **Ecology 6b**. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Investigation and Experimentation
- **1a.** Students will select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

ENGLISH-LANGUAGE ARTS

Grades 9-10

Writing Applications
- **Expository Compositions 2.3**

  a. Marshal evidence in support of a thesis and related claims, including information on all relevant perspectives.

  b. Convey information and ideas from primary and secondary sources accurately and coherently.

  c. Make distinctions between the relative value and significance of specific data, facts, and ideas.

Grades 11-12

Writing Applications
- **Reflective Compositions 2.3**

  a. Explore the significance of personal experiences, events, conditions, or concerns by using rhetorical strategies (e.g., narration, description, exposition, persuasion).

  b. Draw comparisons between specific incidents and broader themes that illustrate the writer's important beliefs or generalizations about life.

  c. Maintain a balance in describing individual incidents and relate those incidents to more general and abstract ideas.

Objectives:

Students will be able to:
- Define nonpoint source pollution and explain how it affects the Upper Newport Bay
- Read and interpret a map showing drainage systems affecting Upper Newport Bay
- Consider some solutions to the problem of nonpoint source pollution

Materials:
- Newport Bay Flood Control & Drainage Map (*www.ocwatersheds.com/watersheds/maps.asp?mapname=highres_map/map55.gif*)
- Handout
  - *Examples of Nonpoint Source Pollution*

Preparation:
- Project or print the flood control and drainage map and make copies for each student group.
- Make a copy of *Examples of Nonpoint Source Pollution* for each student or group.

Time Required:
- Approximately 1 hour

Procedures:

1. Ask students if they know the difference between "point" and "nonpoint" sources of pollution.

2. After discussion, write the following definitions on the chalkboard, overhead, or chart paper, and have a student read them aloud:

   - **Point Source Pollution**: Pollution that originates from a specific place such as a golf course or power plant.

   - **Nonpoint Source Pollution**: Contaminated runoff originating from an undefined place, often an accumulation of sources.

3. Ask students to name as many types of nonpoint source pollution as they can (e.g., pet waste, soaps, lawn fertilizers, litter, motor oil) and list their answers on the board.

4. Discuss the challenges faced in attempting to prevent or reduce nonpoint source pollution versus point source pollution. Ask students why nonpoint source pollution might be more difficult to control. *(For example, point sources, such as factory discharge pipes, are more easily cited and regulated; nonpoint sources, such as people dropping cigarette butts on the sidewalk or washing their cars in the street, are much harder to locate and regulate.*

5. Hand out a copy of the *Examples of Nonpoint Source Pollution* to each student or group. Discuss each pollutant type, where it comes from, and what effects it has on the environment and on humans.

6. Project or hand out to each student or student group a copy of the Flood Control and Drainage Facilities map of Upper Newport Bay. Review the legend together so that students understand what the symbols represent. Identify various locations on the map, such as their school, their homes, a local park. Ask the students:

   a. Where does the water flowing along a gutter lead?
   (It leads to a storm drain, which generally empties into the ocean. During the dry season, however, some of Orange County's runoff might be diverted to treatment facilities.)

   b. When should you see water flowing into storm drains?
   (Water should be flowing in the gutter only after it rains.)

   c. If it is not raining and you see water flowing along gutters, where might it be coming from?
   (This is runoff from irrigating plants, washing cars, watering lawns, cleaning pavement, etc.)

7. Assign a portion of the map to each group, and have the groups identify on their portion where nonpoint sources of pollution originate and what the pollutants may be. Have students list those areas and pollutants on the chart *Examples of Nonpoint Source Pollution*, as well as potential solutions to the problem of each particular pollutant.

8. When all groups have finished, have each group share what they found. Keep a master chart showing locations and pollutants in the Upper Newport Bay watershed.

Follow-up:

1. Have students work in groups or individually to list ways to reduce nonpoint source pollution coming into Upper Newport Bay. For example:

   Keep cars well maintained and free of leaks.
   Recycle used motor oil.
   Do not pour chemicals on the ground or down storm drains.
   Properly dispose of trash in garbage cans.
   Pick up pet waste.
   Don't dispose of leaves or grass clippings in the storm drain; try composting yard waste.
   Landscape yards with native, drought-tolerant plants that do not require fertilizer.
   Prevent runoff by not over-watering.
   Avoid allowing even clean water to run off into gutters.
   Try "natural" (non-toxic) pest control.
   Do not use degreasers, which break down oil, dispersing it throughout water.

2. Have students observe nonpoint source pollution in their local neighborhoods for one week. Ask students to keep a journal recording their observations on the way to and from school and as they travel around the neighborhood. Tell them to indicate the location of storm drains and possible sources of pollution that could make their way into the drainage system. Have them use their observation journals to write reports detailing how nonpoint source pollution could be reduced in their own neighborhoods. Consider sending this report to a city council member or to a local newspaper.

Extensions:

1. Ask students to develop a plan to reduce nonpoint source pollution. How would students go about enforcing it? Find out what measures Orange County is already taking to reduce run-off pollution.

2. Educate others. Discuss why people create nonpoint source pollution and how behavior can be changed. Research safe substitutes for toxic products. Create a handout or posters to educate others about nonpoint source pollution and about how they can help reduce it.

Adapted from "Searching Out Non-Point Sources of Pollution" in *Save Our Seas*, by the Center for Marine Conservation and the California Coastal Commission.

Examples of Nonpoint Source Pollution

Pollutant Types	Sources	Effects	Examples in Upper Newport Bay Watershed	Solutions
Debris *(plastics, glass, metals, wood)*	• roads • parking lots • playgrounds • parks	• can injure or kill wildlife through entanglement or ingestion		
Sediments	• construction sites • agricultural lands • erosion	• clouds water • decreases plant productivity • suffocates bottom-dwelling organisms		
Excess nutrients *(lawn fertilizers, animal wastes, sewage, green waste)*	• livestock • gardens • golf courses • lawns • failing sewage treatment systems	• promotes algae blooms, causing eutrophication which depletes oxygen, harms aquatic life, and causes odor		
Acids, salts, heavy metals	• roads • parking lots • brake dust	• toxic to wildlife and can bioaccumulate in organisms		
Organic chemicals *(pesticides, oil, detergents, etc.)*	• agriculture • boat paints • golf courses and other lawns • failing sewage treatment systems • parking lots	• toxic effects on wildlife and humans • possibly carcinogenic		
Pathogens *(e.g., coliform bacteria)*	• municipal and boat sewage • animal wastes • leaking septic/ sewer systems	• causes typhoid, hepatitis, cholera, dysentery • closes beaches		

Activity: Water Quality

Summary: In this activity, students will test water from Upper Newport Bay or other wetlands for dissolved oxygen, temperature, nitrate, phosphate, pH, and turbidity. Students will analyze the data from their experiments and discuss how various types of pollution affect Upper Newport Bay and other wetlands.

California State Content Standards

SCIENCE

Chemistry
- **Acids and Bases 5a**. Students know the observable properties of acids, bases, and salt solutions.
- **Acids and Bases 5d.** Students know how to use the pH scale to characterize acid and base solutions.

Biology/Life Sciences
- **Ecology 6b**. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Investigations & Experimentation
- **1a.** Students will select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data.
- **1b.** Students will identify and communicate sources of unavoidable experimental error.
- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

ENGLISH-LANGUAGE ARTS

Grades 9-10

Reading Comprehension
- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.6.** Demonstrate use of sophisticated learning tools by following technical directions (e.g., those found with graphic calculators and specialized software programs and in access guides to World Wide Web sites on the Internet).

Objectives:

Students will be able to:
- Perform various water quality tests
- Relate abiotic and biotic parameters
- Interpret data and results of tests

Materials:
- Water samples from various areas in Upper Newport Bay or other source (run-off, tap water, etc.)
- Map of sampling locations (for UNB, suggested collection sites include: Shellmaker Island dock, Back Bay Drive pipe, Back Bay Drive bend, Big Canyon bridge, Big Canyon outfall)
- Dissolved Oxygen TesTabs (2 for each test)
- Nitrate Wide Range CTA TesTabs (1 for each test)
- Phosphorus TesTabs (1 for each test)
- pH Wide Range TesTabs (1 for each test)
- Turbidity test kit (secchi disk)
- Test tubes (1 for each test) labeled:
  - ✓ DO
  - ✓ Nitrate
  - ✓ Phosphate
  - ✓ pH
  - ✓ Salinity
- Distilled water
- Gloves for each group
- Liquid waste container
- Handout
  Testing Procedures

Preparation:

- Apply for permission to collect water samples at your selected site. For Upper Newport Bay, call 949-640-0286 or 949-640-9956.
- Obtain water samples (approximately one liter from each location) and label them to indicate their origin. Keep samples in a cooler until testing.
- Indicate on a map the location for each of the water samples
- Make a copy of the *Testing Procedures* for each student or group.
- Set up a testing station for each water quality test. (See *Testing Procedures*.) Try to have at least two samples—each from a different part of the Bay—for each test.

Time Required:

- Approximately 1 hour

Note: Kits containing materials to conduct the tests are available in scientific supply catalogs as well as online. Earth Force Low Cost Estuary and Marine Kit (Product #5911) can be ordered from www.green.org.

Procedures:

(Note: You need to determine how you want the testing to be carried out. Preferably, set up enough materials at each station so that student pairs can perform each test. Alternatively, divide the class into six groups, have each group perform a different test, and then share results with the class.)

1. Hand out a copy of the *Testing Procedures* to each student or group.

2. Tell students that they are going to be performing various water quality tests. Show students a map indicating where each sample was obtained. Discuss the differences among the sampling locations.

3. Have students read the background for each test and discuss.

4. Point out the six stations and explain the testing procedures. For each test, ask students to predict results before beginning.

5. Have students conduct the tests and record their observations. Remind them to handle all materials carefully.

6. When students have finished their tests, have them dump all test liquids into the liquid waste container. Ask them why the waste liquid should be diluted before disposing of the waste.

Follow-up:

Have each group present their results and discuss their findings.

1. What test results indicated "poor" water quality?

2. What might be the source of that type of pollution in Upper Newport Bay?
(for example, phosphate from soaps and pet waste, nitrate from fertilizer)

3. How do water samples from various areas in the Bay differ? Why do they differ?

4. What sources of error might have affected your results? How could you reduce these errors?

5. What organisms may be affected by poor water quality?

6. How will those effects influence ecosystem balance and function?

7. What might remedy some of the pollution problems?
   (for example, farming organically, using a basin to "catch" some pollution before it enters the Bay, dredging contaminated sediment, keeping waste materials off the street)

8. What could you do to make a difference?

Extensions:

1. Have students research the organisms on the *UNB Inhabitant Cards* (Appendix A) to determine the ideal conditions for each.

2. Record your results in Microsoft Excel and start a water quality log that will track changes over time.

3. Volunteer to be a citizen monitor with your local Surfrider Foundation or borrow their video *Sea to Summit*, which features surf and skate celebrities.
   Visit www.surfrider.org or call 949-492-8170 for more information.

4. Have a speaker from the Municipal Water District of Orange County come to your classroom to discuss local water quality issues. Call the MWDOC Education Department 714-593-5017 for more information.

5. Send students on a "phosphates hunt" to determine what products contain phosphates.

6. Have students do some research to find out what water quality problems have existed historically and how some of those problems have been resolved.

Adapted from "Water Quality Testing" from *Save San Francisco Bay Watershed Education Program*, www.saveSFbay.org

Testing Procedures

DISSOLVED OXYGEN

Dissolved Oxygen (DO) is important to the health of aquatic ecosystems. All aquatic animals need oxygen to survive. Water with consistently high dissolved oxygen levels most likely provides a healthy and stable environment and is capable of supporting a diversity of aquatic organisms. Natural and human-induced changes to the aquatic environment can affect the availability of dissolved oxygen.

Dissolved Oxygen % Saturation is an important measurement of water quality. Cold water can hold more dissolved oxygen than warm water. For example, water at 28°C (82°F) will be 100% saturated with 8 ppm dissolved oxygen. However, water at 8°C (46°F) can hold up to 12 ppm before it is 100% saturated. High levels of bacteria from sewage pollution or large amounts of decaying plants can cause the percent oxygen saturation to decrease. For example, runoff containing nutrients from pet waste or fertilizer can cause algal blooms, which, during decomposition, use up oxygen in the water (eutrophication). This can cause large fluctuations in dissolved oxygen levels, which can affect the ability of plants and animals to thrive.

Testing Procedure

1. Record temperature of the water sample in °C and °F in the space to the right.
2. Rinse the tube labeled "DO" with distilled water and fill it to the top with the water sample.
3. Drop two *Dissolved Oxygen TesTabs* into the sample. Water will overflow when the tablets are added.
4. Screw the cap on the tube. More water will overflow as the cap is tightened. Make sure no air bubbles are present in the sample.
5. Gently shake the tube until the tablets have disintegrated. This will take approximately 4 minutes.
6. Wait five more minutes for the color to develop.
7. Compare the color of the sample to the Dissolved Oxygen Color Chart. Record the result in the space to the right as ppm dissolved oxygen.
8. Locate the temperature of the water sample on the % Saturation chart. Locate the dissolved oxygen result of the water sample at the top of the chart. The % Saturation of the water sample is where the temperature row and the dissolved oxygen column intersect (e.g., if the water sample temperature is 16°C and the dissolved oxygen result is 4 ppm, then the % Saturation is 41). Record this number as % Saturation in the space to the right.

°C
°F

Result:
ppm

Result:
% Sat

% Saturation Chart
Dissolved Oxygen

TEMP °C	0 ppm	4 ppm	8 ppm
2	0	29	58
3	0	31	61
6	0	32	64
8	0	34	68
10	0	35	71
12	0	37	74
14	0	39	78
16	0	41	81
18	0	42	84
20	0	44	88
22	0	46	92
24	0	48	95
26	0	49	99
28	0	51	102
30	0	53	106

Conversion: °F = (°C x 1.8) + 32

Ranking the Test Results

91 - 110% Sat	Excellent
71 - 90% Sat	Good
51 - 70% Sat	Fair
< 50% Sat	Poor

TEMPERATURE

Temperature is very important to water quality. Temperature affects the amount of oxygen in the water and the rate of photosynthesis by aquatic plants. Most aquatic plants and animals are adapted to a specific temperature range and may die if the temperature of the water changes. An example of thermal pollution is hot water from an industrial plant being emptied into a body of water – such as cooling water from a power plant or a refinery. Also, rivers with channelized banks experience higher temperatures because of the lack of shading from vegetation.

Testing Procedure (for field study only)

1. Place the thermometer 4 inches below the surface of the water for one minute.
2. Remove the thermometer from the water and read the temperature. Record the temperature in °C and °F in the space to the right.

°C
°F

Ranking the Test Results	
Temp < 26 °C	Good
Temp > 26 °C	Poor
Conversion: °F = (°C x 1.8) + 32	

NITRATE

Nitrate is a nutrient needed by all aquatic plants and animals to grow. Dead plants and animals and animal wastes naturally release nitrate into the aquatic system. High levels of nitrate can lead to overgrowth of plants, increased bacteria, and decreased oxygen levels. Human sewage, fertilizer, and agricultural runoff all contribute to high levels of nitrate.

Testing Procedure

1. Rinse with distilled water and then fill the test tube labeled "Nitrate" to the 5 mL line with a water sample.
2. Add <u>one</u> *Nitrate Wide Range CTA TesTab* to the sample.
3. Cap the test tube and gently shake it until the tablet has disintegrated. Bits of the material may remain in the water sample.
4. Wait five minutes for the color to develop.
5. Compare the color of the sample to the Nitrate color chart. Record the result in the space as ppm Nitrate.

Result:
% Sat

Ranking the Test Results	
0 – 5 ppm	Good
5 – 20 ppm	Poor
20 – 40 ppm	Very Poor

PHOSPHATE

Phosphate is a nutrient needed by plants and animals to grow. Like nitrate, high levels of this nutrient can lead to overgrowth of plants, increased bacteria, and decreased oxygen levels. Phosphate comes from several sources, including soaps, human and animal waste, industrial pollution, and agricultural runoff.

Testing Procedure

1. Rinse with distilled water and then fill the test tube labeled "Phosphate" to the 10 mL line with a water sample.
2. Add one *Phosphorus TesTab* to the sample.
3. Cap the test tube and gently shake it until the tablet has disintegrated. Bits of the material may remain in the water sample.
4. Wait five minutes for the blue color to develop.
5. Compare the color of the sample to the Phosphate Color Chart. Record the result in the space as ppm phosphate.

Result: ppm

Ranking the Test Results

0 – 1 ppm	Excellent
2 – 4 ppm	Good
4+ ppm	Poor

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pH

pH is a measurement of the amount of acid or alkaline (base) in the water. The pH scale ranges from a value of 0 (very acidic) to 14 (very basic), with 7 being neutral. The pH of tap water is usually between 6.5 and 8.2. Most aquatic plants and animals are adapted to a specific pH level and may die if the pH of the water changes even slightly. pH can be affected by industrial waste and agricultural runoff.

Testing Procedure

1. Rinse with distilled water and then fill the test tube labeled "pH" to the 10 mL line with a water sample.
2. Add one *pH Wide Range TesTab* to the sample.
3. Cap the test tube and gently shake it until the tablet has disintegrated. Bits of the material may remain in the water sample.
4. Compare the color of the sample to the pH color chart. Record the result in the space as pH.

Ranking the Test Results

6 – 8	Good
4 – 5	Poor
9 – 10	Very Poor

Result: pH

Turbidity

Turbidity is the measure of the clarity of water. Turbid water is caused by suspended matter such as clay, silt, and microscopic organisms. Turbidity should not be confused with color, since darkly colored water can still be clear and not turbid.

With decreased clarity, aquatic organisms receive less sunlight, affecting the food chain from the bottom up.

Turbid water may be the result of soil erosion, urban runoff, algal blooms, and bottom sediment disturbances, which can be caused by dredging, wave action, boat traffic and abundant bottom feeders.

Testing Procedure

1. Fill the tube with the secchi disk on the bottom with the water sample.

2. Look down into the tube and compare the appearance of the secchi disk to the Turbidity Chart. Record the result in the space below as Turbidity in Jackson Turbidity Units (JTU).

Result:

JTU

Ranking the Test Results

0	Excellent
0 – 40	Good
40 – 100	Fair
> 100	Poor

Activity: Pollution Observation

Summary: In this activity, students will conduct an experiment to observe the effects of nonpoint source pollution on water environments.

California State Content Standards

SCIENCE

Chemistry
- **Acids and Bases 5a.** Students know the observable properties of acids, bases, and salt solutions.

Biology/Life Sciences
- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
- **Ecology 6d.** Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.

Earth Sciences
- **Biogeochemical Cycles 7a.** Students know the carbon cycle of photosynthesis and respiration and the nitrogen cycle.

Investigation and Experimentation
- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- **1d.** Students will formulate explanations by using logic and evidence.
- **1g.** Students will recognize the usefulness and limitations of models and theories as scientific representations of reality.
- **1j.** Students will recognize the issues of statistical variability and the need for controlled tests.

Objectives:

Students will be able to:
- Record and interpret observations of the effects different types of nonpoint source pollution have on water environments
- List possible effects of pollution on wildlife in Upper Newport Bay

Materials:

- 5 clear 1-quart or larger containers (plastic soda bottles or canning jars)
- Water that contains algae from a freshwater aquarium or a pond, or pond water purchased from a biological supply company (at least 5 quarts)
- Good light source (direct sunlight or strong artificial light)
- Plant fertilizer (7 teaspoons)
- Motor oil (2 teaspoons)
- Vinegar (1/2 cup)
- Dish detergent (2 tablespoons)
- Masking tape or blank labels
- Markers
- Handout
  - *Observation Sheet*

Preparation:

- Two weeks before the lesson, set up the five bottles or jars. Fill each jar with aquarium or pond water, add one teaspoon of plant fertilizer, and stir thoroughly. To improve the quality of the model, try adding a bit of soil from the bottom of a pond or gravel from an aquarium tank along with the water. Put the jars without lids near a window where they will get direct light or give them a strong incandescent or fluorescent light. Do not put them where they will get cold. Let the jars sit for 2 weeks.
- The day of the lesson, set up 4 testing stations. Each station should have a jar, tape and marker for labeling, measured amount of one of the pollutants (2 teaspoons of motor oil, 1/2 cup of vinegar, 2 tablespoons of detergent, 2 teaspoons of fertilizer), and an *Observation Sheet*.

Time Required:

- 1 hour for initial lesson
- 5 minutes twice a week for 4 weeks for observations
- 1 hour for final lesson

Adapted from "Recipe for Trouble" in *WOW! The Wonders Of Wetlands,* co-published by International Project WET and Environmental Concern

Procedures:

1. Tell students that they will be conducting an experiment to see how pollution affects water environments such as Upper Newport Bay. Show students the five jars. Explain that each contains water and some added nutrients, in the form of fertilizer, to feed the plants in the water.

2. Explain that one jar will be the control, and the other four will each have a “pollutant” added to them. Point out each pollutant and ask students how that pollutant might get into the Bay.
   Motor oil – from cars and car repair shops; washes off streets and parking lots and runs into storm drains or creeks
   Detergent – from car washing, dog washing, patio washing; runs off into storm drains or creeks
   Vinegar – represents acid rain or acidic runoff from manufacturing
   Fertilizer – from agriculture, gardens, pet waste, parks, golf courses; runs off into storm drains or creeks.

3. Divide students into four groups and direct each group to a different station. Direct students to label their jar with the name of the pollutant they will be adding, and to record what they observe in the jar before adding the pollutant. Have students predict what will happen to the jar of water, both immediately and over time, and record their predictions on the sheet.

4. Ask students to carefully add the pollutant to their sample and to record their immediate observations of changes. Ask students to cover the jars lightly (covering tightly might lead to the growth of some undesirable bacteria). Put the jars in the light as before.

5. Twice a week for the next four weeks, have students check their jars and record notes on their *Observation Sheet*. (*OPTION: Use a camera to take pictures of the samples each week.*) At the end of week 4, have each group give a brief report to the class on their observations.

Follow-up:

Ask students the following questions:

1. Why is the fertilizer, which is a nutrient and promotes plant growth, considered a “pollutant”?
   (The algae grow too quickly, disrupting the balance of organisms. When the algae die and decompose, the oxygen in the water is depleted because of microbial activity—called eutrophication. The lack of oxygen can harm plants and animals living in the water. Many plants and other organisms that can't move, such as clams, will suffocate.)

2. Why did the vinegar make the water so clear?
   (The water became clear because the acid in the vinegar killed everything in the water.)

3. Why can some organisms survive under a layer of oil?
   (If the algae can get enough sunlight, they can produce enough oxygen to keep themselves—and other organisms that live below the oxygen-impervious oil layer—alive.)

4. What wildlife can be harmed by oil in the water?
   (Animals that come into contact with oil are harmed. Aquatic birds and mammals that get coated with oil are unable to fly or stay warm. Fish gills can be clogged.)

5. How can wetlands help lessen the effects of pollutants?
   (Because they are able to process excess nutrients and toxins, wetland plants can filter out many pollutants before they have a chance to enter larger water bodies. Too many pollutants, however, can begin to kill wetland plants and animals.)

6. What can you do to decrease the amount of these pollutants that reach the water?
   (For example, properly maintain cars, pick up pet waste, use commercial car washes.)

Extensions:

1. Have students devise methods to reverse or improve the water quality in their model polluted systems. For example:
   — Add baking soda to the acid test to neutralize the acid. (This is similar to adding lime or limestone rocks to lakes or streams to neutralize the effects of acid rain.)
   — Mop up the oil spill with straw, feathers, or cotton. Can students skim the oil off of their models to let the oxygen through again?

2. Have students research and write a report on what is being done to keep pollutants off the street. For example:
   — sweeping streets
   — mailing information sheets
   — providing pet-waste bags in parks
   — stenciling storm drains with "Leads to Ocean"
   — setting "Total Maximum Daily Load" (TMDL) requirements for pollutants

Adapted from "Recipe for Trouble" in *WOW! The Wonders Of Wetlands,*
co-published by International Project WET and Environmental Concern

Observation Sheet

Pollutant: ____

Appearance before adding pollutant: ______________________________

____

Predictions: ____

____

____

Appearance immediately after adding pollutant: ______________________

____

Week 1: ____

____

Week 2: ____

____

Week 3: ____

____

Week 4: ____

____

Possible Sources of Error: ______________________________________

____

Conclusions: ____

____

____

____

Activity: Space for Species

(Field Study)

Summary: Students will survey plant diversity in a habitat they are familiar with—their schoolyard, park, or some other local area. Students learn how to make and interpret the species-area curve, one tool scientists use to investigate the level of biodiversity in a habitat.

California State Content Standards

SCIENCE

Biology/Life Sciences
- **Ecology 6a.** Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
- **Evolution 8b.** Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.

Investigation and Experimentation
- **1a.** Students will select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- **1d.** Students will formulate explanations by using logic and evidence.
- **1g.** Students will recognize the usefulness and limitations of models and theories as scientific representations of reality.
- **1k.** Students will recognize the cumulative nature of scientific evidence.

MATHEMATICS

- **Probability and Statistics 8.0.** Students organize and describe distributions of data by using a number of different methods, including frequency tables, histograms, standard line and bar graphs, stem-and-leaf displays, scatterplots, and box-and-whisker plots.

Objectives:

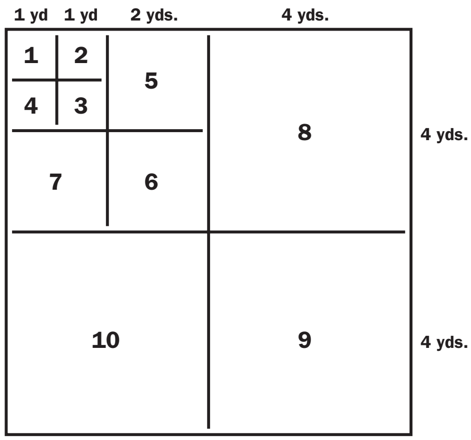
Students will be able to:
- Create a graph that demonstrates the relationship between species richness and the size of a habitat
- Describe factors that affect the relationship between habitat fragmentation and biodiversity

Materials:

- Plot of land 64 square meters (approximately 830 square feet) containing at least 12 different species of plants from which leaves can be taken (e.g., schoolyard, roadside field, local park)
- Stakes (e.g., pencils or coffee stirrers)
- Twine
- Tape measure (8 meter or 30 foot length)
- Large clear plastic bags
- Easel with chart paper or butcher paper and marker
- Clear tape
- Graph paper
- Handout
  - *Leaf I.D.*

Preparations:

- Mark off an 8 meter by 8 meter square and divide it into 10 plots as shown below using stakes and twine. Place a large clear plastic bag in each plot and mark the plot number on the bag.



- Make a copy of the *Leaf I.D.* handout for each student or student group.
- On chart paper or butcher paper, prepare the Data Log (see sample, without the leaves and the Xs).
- On chart paper, prepare a Data Summary Table (see sample, without the numbers).

Time Required:

- Approximately 20 minutes for leaf gathering
- Approximately 50 minutes for data summary, graphing, and discussion

Procedures:

Part I – Collecting Leaves

A. Introduce fragmentation

1. Tell students that they are going to be investigating the diversity of plants in their schoolyard (or field or park) and determining if there are different numbers of species in habitats of different sizes.

2. Explain that many people are concerned about how the size of habitats affects biodiversity because we are breaking up many species' habitats into small chunks by building roads, homes, shopping centers, and other developments—a process called fragmentation. Tell students that many scientists are trying to better understand how fragmentation affects biodiversity. Ask students how they think biodiversity is affected by this dividing up of habitats. What types of species might be affected first (birds or lizards, rabbits or mountain lions)?

B. Explain collection procedure

1. Point out the marked off plots and tell students that each plot represents a different-sized habitat. Explain that they will be counting the number of plant species in each of the different plots. Ask for predictions about how they think a habitat's area will affect the number and types of species it contains.

2. Explain that in each plot they are to take a leaf from each different plant species they find and put it in the plastic bag in that plot. Stress that they should be as gentle as possible and that they should try not to take more than one leaf from each species.

3. Review with students how to tell different plant species apart. Pick leaves of two very different species and ask students how they can tell that the leaves are from two different kinds of plants. Press students to be specific about how the leaves differ. Pick leaves of two different species that look more similar and ask students again to be specific in telling how the leaves are different. Hand out to students the *Leaf I.D.* sheets and point out some basic leaf characteristics that students can use to tell one kind of plant from another (shape, venation, color, hair, edges).

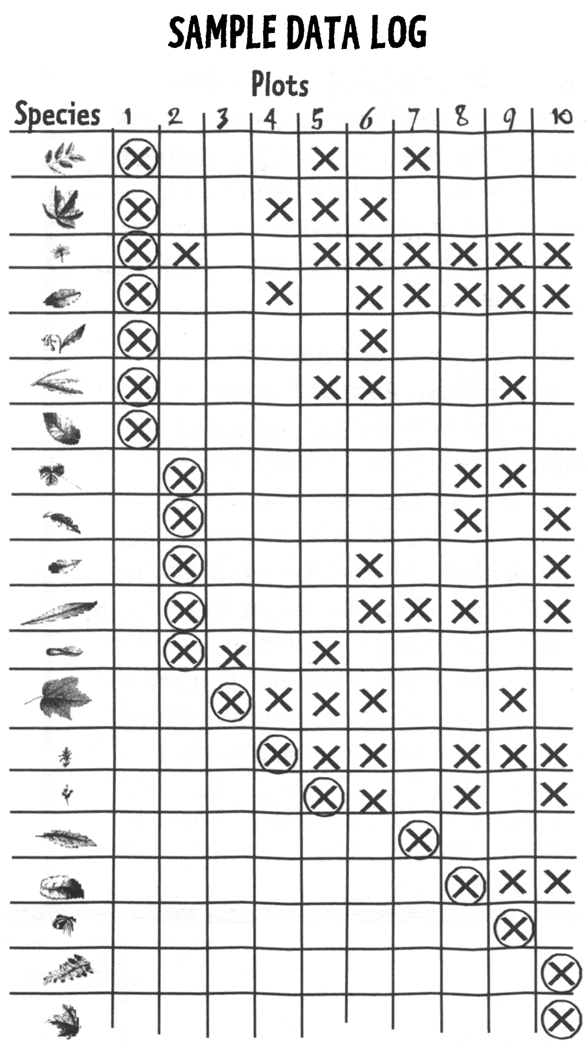
4. Divide the class into 10 groups. For a class of 25, assign:

   - 1 student for each 1-square-meter plot (plots 1, 2, 3, 4)
   - 3 students for each 4-square-meter plot (plots 5, 6, 7)
   - 4 students for each 16-square-meter plot (plots 8, 9, 10)

   If you have more than 25 students, have them alternate collecting plants so that the area does not become too crowded. (Have alternates work on drawing the chart or recording data.) If you have fewer than 25 students, reduce the number of students in the midsize plots first and in the large plots second.

C. Collect the samples

Allow students time to collect their samples. Remind them to continually compare the leaves so that only one leaf from each species is in their bags.



Part II – Plotting the Species-Area Curve

A. Log the samples

1. Once the collection is complete, have each group sort through the samples in their bag to make sure that they have only one sample of each species. Tell them that if they have more than one, they should select the leaf that is in the best condition to represent that species.

2. Point out the Data Log you have prepared and explain to students that they are going to record all the various species they found and in what plots each species was found.

3. First, have the student(s) from plot 1 tape up a sample of each species in the "Species" column and put an X under the "Plot 1" column next to each leaf to show that that species was first found in plot 1 (see sample log).

4. Next, have the student(s) from plot 2 post their samples. Tape up only samples of new species and place an X in that species' row under "Plot 2" to show that it first appeared in plot 2. If the plot 2 collection contains a sample of a plant that is already on the Data Log, simply mark an "X" in that species' row under "Plot 2."

5. Continue this procedure for all 10 plots.

B. Fill in the Data Summary Table

1. Have students use the information in the log to fill in the Data Summary Table. Explain that the "Total Number of Species" row indicates the cumulative total of species found as each plot is added, and the "Total Sample Area" row indicates the cumulative area as each plot is added. (See sample below.)

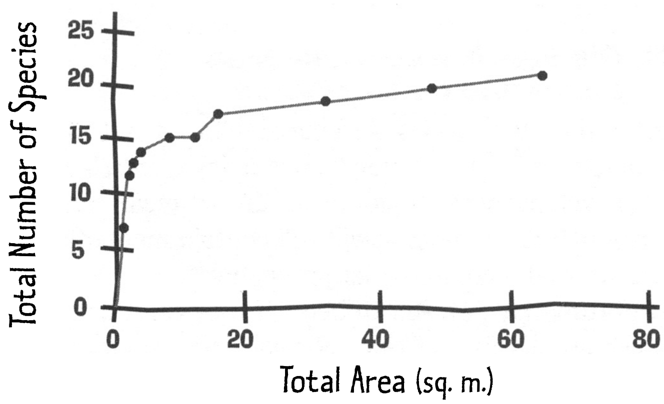
SAMPLE DATA SUMMARY TABLE

Plot Number	1	2	3	4	5	6	7	8	9	10
New Species (first seen in sample area; ⊗s in this plot)	7	5	1	1	1	0	1	1	1	2
Total Number of Species (all ⊗s up to now)	7	12	13	14	15	15	16	17	18	20
Plot Area (sq. yd.)	1	1	1	1	4	4	4	16	16	16
Total Sample Area (total of plot areas in sq. m.)	1	2	3	4	8	12	16	32	48	64

2. Tell students that this table will give them the data they need to create a graph that will indicate the relationship between the size of the habitat and the number of plant species in it.

C. Graph the results

1. Either work together as a class, or have students work in groups to graph the results of their sampling. Tell students that the x-axis should be labeled "Total Area" and the y-axis should be labeled "Total Number of Species." (See sample graph below, which is based on the sample Data Summary Table.)



2. Point out that:
   - data for the x-axis comes from the "Total Sample Area" row of the Data Summary Table
   - data for the y-axis comes from the "Total Number of Species" row of the Data Summary Table
   - the number of data points—10—equals the number of plots.

3. Explain to students that the graph they have created is called a "Species-Area Curve" and that it shows the relationship between habitat size and the number of species in the habitat.

D. Interpret the graph

1. Show students the sample graph above and ask if their graph has the same general shape. If it does, tell students that the curve they made based on their schoolyard or local park habitat is a lot like curves made from samples in other kinds of habitats. Explain that most species-area curves have this general shape; that is, the curve will usually rise sharply at the small plot areas, then more slowly as the area increases, and eventually plateau after the common species have been accounted for.

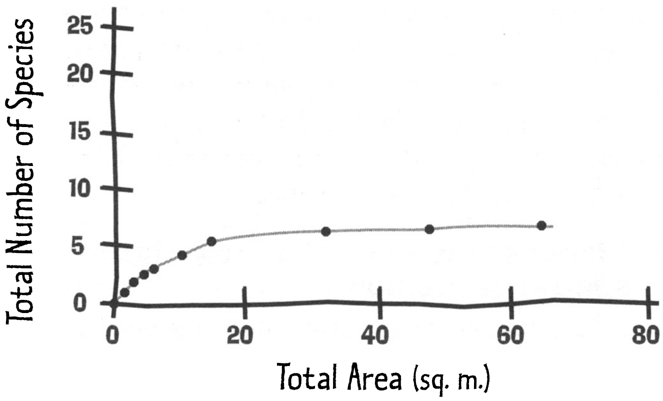
2. Ask students why they think species-area curves usually look this way.
   *(In general, most species in North America are commonly found throughout their habitat. In other words, you would probably see in a 10-square-meter plot of forest most of the trees, birds, or mammals that live in a 50-square-meter plot of the same forest. But as you looked at larger and larger plots, your chances of finding rare species or species that require special resources would increase. Thus, the curve usually rises quickly at the small plot areas, then more slowly as the area increases. [**Note:** Species that are top predators, such as big cats and birds of prey, may be rare in a habitat because they are territorial or need a lot of space to find food. Species can also be naturally rare if they have more specialized needs such as a certain type of soil or food. These species would be found only where the resources they need are found.])*
3. Help students interpret the graph and understand the various uses of the species-area curve. For each point below, ask students how they think the graph is used.

   - **To figure out how much of a habitat must be sampled in order to accurately estimate the number of species present.**
     (Scientists can look where the slope approaches zero, or where very few new species are added, to determine what size plot will contain most of the species in the habitat. Based on the sample curve, for example, a scientist would look at a 20-square-yard plot to find most of the plant species in the habitat.)

     - Ask students what size plot they would have to survey to make an accurate estimate of the number of plants in the schoolyard (or park).

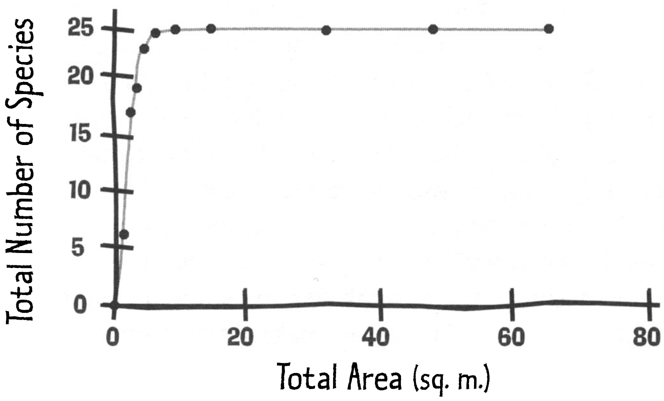
   - **To compare different habitats.**
     (Different habitats can have curves with different shapes; for example, the steepness of the slope—representing the rate of new species present—or the point where the curve levels off—an indication of the number of common species—can vary.. Each graph will give information about the biodiversity of its respective habitat.)

- Draw a species-area curve that is less steep and that levels off at a lower number of species than the one you made as a class. (See the example below; perhaps change the numbers on the y-axis to be more like the numbers of species your students found.)



- Ask students what this shape tells us about how the species in this habitat compare to ones in the habitat they explored.
  (There are fewer kinds of species in this habitat than in the habitat students explored.)

- Draw a species-area curve that is very steep and levels off quickly at a high number of species, such as the example below. Ask students how this habitat compares to their habitat.
  (This habitat has very high biodiversity, and the species seem to be tightly packed, such as in a rainforest. A very small plot would capture most species in the habitat. In the students' study area, species are likely more spread out, and there are probably fewer species.)



- **To look at one habitat over a long period of time to see how its species richness changes.**
  (Surveying the same area at different times of year or after major disturbances, such as big storms, insect population explosions, or pesticide applications, can determine if these events have changed the species-area relationship.)

Follow-up:

1. Ask students what the species-area curve tells us about the problem of fragmentation. (*Habitats with higher diversity are more resilient. Rare and territorial species are lost first*.)

2. Point out that since many curves level off at relatively small plot areas, it may seem that small habitat fragments will still contain most of the species that were in the larger habitat. Tell students that unfortunately, that is not true. Ask if they can think of any reasons why this isn't true. Could the species-area curve be used in designing the size of an ecological reserve?

3. Remind students that they looked at plots that were part of a larger habitat; they weren't looking at habitat fragments. Point out that in species-area curves, new species continue to appear after the curve has leveled off. Explain that if we cut a habitat's size to a point where even a few of these species are lost, we may be losing some important species, such as top predators. Point out that these keystone species, which often require large areas in which to hunt, play vital roles in habitat function and food web balance and that scientists use keystone species as indicators of functioning ecosystems. Emphasize that without them, the habitat and species in it could change.

4. Explain that like islands, habitat fragments are often too small and isolated to support a large number or a wide variety of species and that many species struggle to survive in fragmented landscapes. Tell students that in general, smaller areas have fewer species. Ask students if, with this information, they would build a house in the middle of functioning habitat or on the edge.

Extensions:

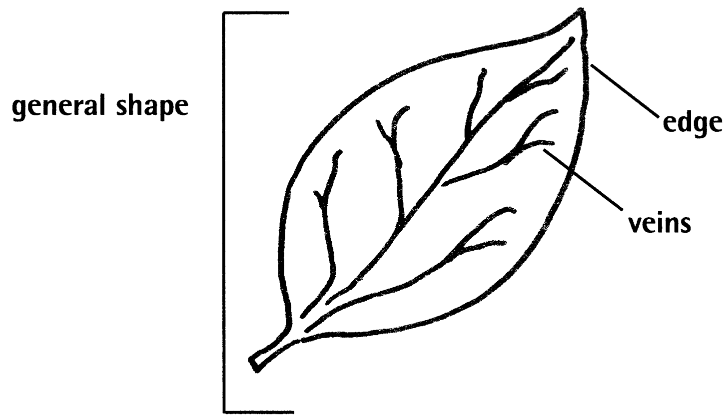
1. Stage an in-class debate about a current development issue in your area. Have half the students in favor of developing the land and the other half against it. Those in favor of development should be able to cite some of the potential social and economic benefits of the proposed project, and those opposed should cite some of the project's potential environmental consequences, especially its potential effect on biodiversity.

2. Look for habitat fragments in your community, e.g., fragments of pine forests, beach-dune systems, or grasslands. Then take a field trip to investigate some different-sized fragments of the same type. Have students think of ways they could investigate the level of biodiversity in the fragments, and then compare the fragments.

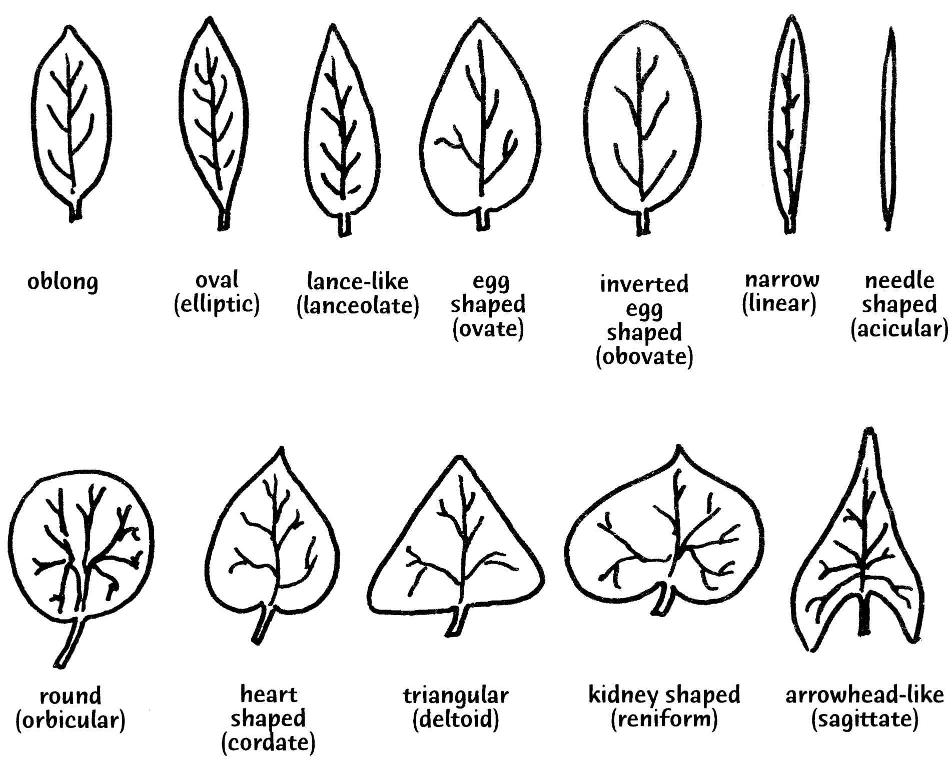
3. Get involved in biodiversity monitoring projects. Check the following websites:

   - www.audubon.org
   - www.learner.org/jnorth/
   - www.defenders.org
   - www.sprise.com/shs/habitatnet/MonitoringProject.htm

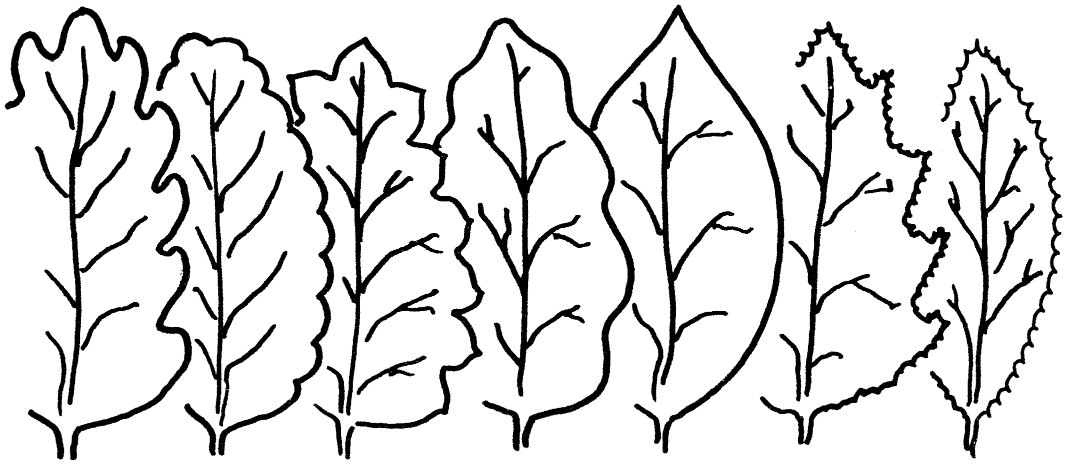
One way to tell plants apart is by looking at their leaves



Shapes

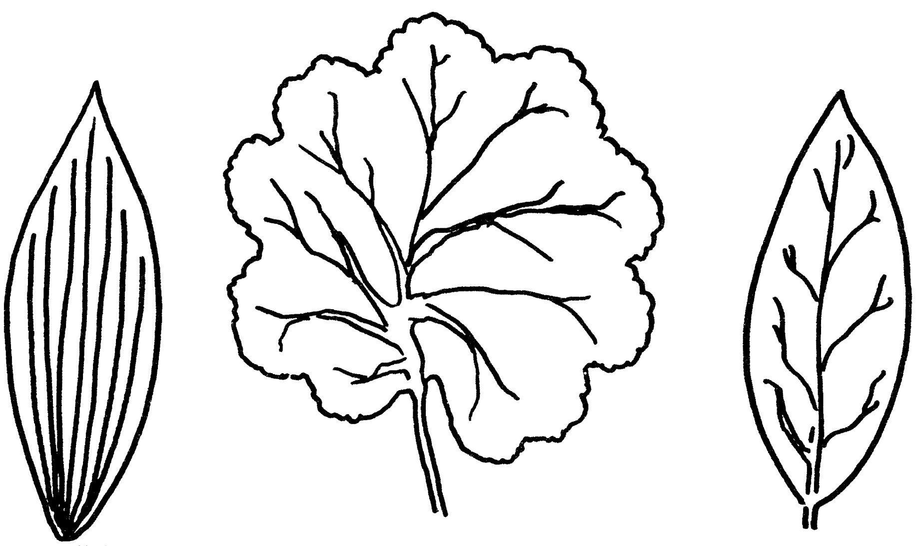


Edges



lobed | rounded (crenate) | tooth-like (dentate) | wavy (undulate) | smooth (entire) | double saw-like (double serrate) | saw-like (serrate)

Veins (There are three main ways that veins are arranged on leaves.)



parallel | palmate | pinnate

Activity: Species In Peril

Summary: In this activity, students will discover the distinctions between threatened, rare, and endangered species, prepare a report on threatened or endangered species that live in the Upper Newport Bay, and explore the factors affecting species' status.

California State Content Standards

SCIENCE

Biology/Life Sciences

- **Ecology 6a.** Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
- **Ecology 6c.** Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.
- **Evolution 8b.** Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.

ENGLISH-LANGUAGE ARTS

Grades 9-10

Reading Comprehension

- **Structural Features of Informational Materials 2.2.** Prepare a bibliography of reference materials for a report using a variety of consumer, workplace, and public documents.
- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.5.** Extend ideas presented in primary or secondary sources through original analysis, evaluation, and elaboration.

Writing Strategies

- **Organization and Focus 1.1.** Prepare a bibliography of reference materials for a report using a variety of consumer, workplace, and public documents.
- **Organization and Focus 1.2.** Use precise language, action verbs, sensory details, appropriate modifiers, and the active rather than the passive voice.
- **Research and Technology 1.3.** Use clear research questions and suitable research methods (e.g., library, electronic media, personal interview) to elicit and present evidence from primary and secondary sources.
- **Research and Technology 1.4.** Develop the main idea within the body of the composition through supporting evidence (e.g., scenarios, commonly help beliefs, hypotheses, definitions).
- **Research and Technology 1.5.** Synthesize information from multiple sources and identify complexities and discrepancies in the information and the different perspectives found in each medium (e.g., almanacs, microfiche, news sources, in-depth field studies, speeches, journals, technical documents).

Writing Applications

- **Expository Compositions 2.3**
  - **a.** Marshal evidence in support of a thesis and related claims, including information on all relevant perspectives.
  - **b.** Convey information and ideas from primary and secondary sources accurately and coherently.
  - **c.** Make distinctions between the relative value and significance of specific data, facts, and ideas.
  - **d.** Include visual aids by employing appropriate technology to organize and record information on charts, maps, and graphs.
  - **e.** Anticipate and address readers' potential misunderstandings, biases, and expectations.
  - **f.** Use technical terms and notations accurately.

Listening and Speaking Strategies

- **Organization and Delivery of Oral Communication**
  1.7. Use props, visual aids, graphs, and electronic media to enhance the appeal and accuracy of presentations.

Speaking Applications

- **Deliver Expository Presentations 2.2**
  a. Marshal evidence in support of a thesis and related claims, including information on all relevant perspectives.
  b. Convey information and ideas from primary and secondary sources accurately and coherently.
  c. Make distinctions between the relative value and significance of specific data, facts, and ideas.
  d. Include visual aids by employing appropriate technology to organize and display information on charts, maps, and graphs.
  e. Anticipate and address the listener's potential misunderstandings, biases, and expectations.
  f. Use technical terms and notations accurately.

Grades 11-12

Writing Strategies

- **Research and Technology 1.6.** Develop presentations by using clear research questions and creative and critical research strategies (e.g., field studies, oral histories, interviews, experiments, electronic sources).
- *Research and Technology* **1.8.** Integrate databases, graphics, and spreadsheets into word-processed documents.

Listening and Speaking Strategies

- **Organization and Delivery of Oral Communication**
  1.8. Use effective and interesting language, including:
  a. Informal expressions for effect
  b. Standard American English for clarity
  c. Technical language for specificity.

Objectives:

Students will be able to:

- Define *native* and *non-native* species
- Define *threatened*, *rare*, and *endangered* species
- Become familiar with state and federal processes for listing and protecting threatened and endangered wildlife
- Identify threatened or endangered species in Upper Newport Bay and the factors that contribute to their peril

Materials:

- Handouts
  The Endangered Species Act
  Species In Peril chart
  Threatened and Endangered Species
  Report Guide

Preparation:

- Make a copy of *The Endangered Species Act* handout for each student
- Make a transparency of the *Species In Peril* chart or make a copy for each student.
- Make seven copies of the *Report Guide*.
- Make an overhead of the *Species Status Table* (on the *Report Guide*) or copy it onto the board or chart paper.

Time Required:

- Class time – about 2 class periods
- Research time – flexible

Procedures:

1. Hand out a copy of *The Endangered Species Act* to each student. Read and discuss the information. Ask students why the extinction of a species matters.

2. Place a copy of the *Species in Peril* chart on the overhead projector (or give a copy to each student). Discuss the definition of each term. Use the following questions to generate a discussion.
   Why do you think these definitions were developed? How are they useful?
   Do you think any definitions could be improved?
   How might non-native species pose problems for threatened or endangered species?
   How might human activity be a problem for threatened species?
   How do you think protection of threatened or endangered species could be improved?

3. Explain that there are seven threatened or endangered species in Upper Newport Bay. Divide the class into seven groups and tell students that each group will prepare a report on one of the nine threatened or endangered species in Upper Newport Bay.

4. Hand out a copy of the *Report Guide* to each group. Assign a different species from the S*pecies Status Table* to each group. Encourage students to call land managers at Orange County Public Facilities and Resources Department or at the Department of Fish and Game, to interview long-time residents, to use the Internet, and to read books and articles to gather information.

5. Tell students how much time they have to prepare their reports. Arrange for students to have some class time to work together on their reports.

6. Have each group present its report to the class, answering the questions on the *Report Guid*e. Place a copy of the *Species Status Table* on the overhead (or copy it onto the board or chart paper). As each group reports, fill in the *Species Status Table.*

Follow-up:

Discuss the *Species Status Table*.

1. Ask why some species are on the California list but not on the federal list.
   (These differences occur because habitats, and the species that live in them, cross state lines. An animal or plant may have been lost within one state's boundaries, but may be abundant in another and therefore not considered threatened federally by USFWS.)

2. Discuss the factors affecting each species. Do some factors affect more than one species? How could the impact of some of these factors be reduced?
   (Setting conservation priorities based on public definition of which species are most "lovable" is clearly not ideal.)

3. Discuss strategies to protect multiple species under one recovery plan.

4. Have students guess which species group has the most listings. Which group receives the most recovery funds?
   (31 Mammals, 13 Reptiles, 12 Amphibians, 33 Birds, 34 Fish, 218 Plants, 32 Invertebrates species are listed. Seventy percent of listed mammals are afforded protection; in contrast, the average percentage of protection for all other taxa is less than 15%. Plants are the least protected: they represent 50% of the listed species yet they receive only 8% of the recovery funds.)

Extensions:

1. Research an invasive species in Upper Newport Bay (e.g., wild mustard, pampas grass, African clawed frog). Explain how it is impacting native California species, and describe possible solutions to the problem.

2. Research native species in your area. Try to find native species in nature. Record observations such as: location, habitat description, abundance, cohabitants, and competitors.

3. Write a report on how the Endangered Species Act could be improved. Identify taxonomic bias by comparing the number of animals and plants or birds and fish that have been listed. What percent of recovery funds are spent on whales versus trees? Are the standards against which decisions for selecting species to list as endangered or threatened objective and measurable? How many species have been delisted?

Adapted from "What's So Special About Native Species?"
in *Waves, Wetlands, and Watersheds: California Coastal Commission Science Activity Guide*

The Endangered Species Act

Although extinction is a natural process, human activities have caused a dramatic increase in its rate. Human beings have become a hundred times more numerous than any other land animal of comparable size in the history of life. Our species appropriates 40 percent of the solar energy captured in organic material by plants. Drawing upon the resources of the planet to such a degree drastically affects other species. Some scientists estimate that human activity is responsible for the extinction of 100 plants and animals each day—that's almost four species extinctions per hour. Other scientists offer lower figures, but few experts disagree that the rate of species extinction is being accelerated by human actions.

The U.S. Endangered Species Act of 1973 gives authority the U.S. Secretary of the Interior, or in the case of marine species to the Secretary of Commerce, to place species on an endangered list. Implementation of the Endangered Species Act is overseen by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service. Proposals to list or delist a species are published in the *Federal Register*, a U.S. government publication, and after a public comment period, the USFWS decides whether to approve, revise, or withdraw the proposal. In California, the Department of Fish and Game identifies the state's species of concern.

Listed species have special protection, and any project that threatens one of these species must undergo an intensive review. The endangered species list includes recovery plans for each species, detailing the tasks needed to reach a level where protection for that species is no longer necessary.

Species In Peril

Term	Definition	Example
Species	In biology, the most fundamental classification of living things, comprising individuals that successfully interbreed	Humans
Native species	Species that have evolved over thousands of years in a particular region. They have adapted to the geography, hydrology, and climate of that region.	California Sagebrush, California Buckwheat
Non-native species	Species that have been introduced into an environment in which they did not evolve	Wild Mustard, Ice Plant
Rare species	A species of concern because of low numbers. (Some species are naturally rare because of their reproductive rate or habitat specializations)	Coast Woolly Heads, Southern Tarplant, Estuary Seablite, Many-stemmed Dudleya
Threatened species	Any species which is likely to become an endangered species in the future	California Black Rail, California Gnatcatcher
Endangered species	Any species which is in danger of extinction throughout all or a significant portion of its range	California Least Tern, Salt Marsh Bird's Beak, Light-footed Clapper Rail, Belding's Savannah Sparrow, Brown Pelican

Threatened and Endangered Species Report Guide

Write a three-page report and create a five to ten minute in-class presentation. Include the following:

1. Basic information about the species, including illustrations and/or photographs. Be sure to include information about habitat, feeding preferences, and special adaptations
2. Past and current range, including map(s)
3. Migration patterns (if applicable), including maps or other graphics
4. Reason for endangered or threatened species listing. What are the threats to this species in Upper Newport Bay?
5. Current status
6. Steps being taken to preserve the species
7. Bibliography of sources

Internet links for research:
www.dfg.ca.gov/hcpb/species/p_a_rglr/genplantsanimals.shtml

Species Status Table

Species	**California Status**	**Federal Status**	**Factors Affecting Status**
Brown Pelican			
California Gnatcatcher			
Light-footed Clapper Rail			
California Black Rail			
California Least Tern			
Belding's Savannah Sparrow			
Salt Marsh Bird's Beak			

Activity: Castaways Park

Summary: In this activity, students will consider a current land-use issue in Upper Newport Bay—landscaping a park with native versus non-native plants—present viewpoints held by different interest groups in favor of various options, and evaluate the arguments to make a final decision.

California State Content Standards

SCIENCE

Biology/Life Sciences

- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Investigation and Experimentation

- **1m.** Students will investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings.

ENGLISH-LANGUAGE ARTS

Grades 9-10

Reading Comprehension

- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.3.** Generate relevant questions about readings on issues that can be researched.
- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.5.** Extend ideas presented in primary or secondary sources through original analysis, evaluation, and elaboration.

Listening and Speaking Strategies

- **Comprehension 1.1.** Formulate judgments about the ideas under discussion and support those judgments with convincing evidence.
- **Organization and Delivery of Oral Communication 1.6.** Present and advance a clear thesis statement and choose appropriate types of proof (e.g., statistics, testimony, specific instances) that meet standard tests for evidence, including credibility, validity, and relevance.
- **Organization and Delivery of Oral Communication 1.9.** Analyze the occasion and the interests of the audience and choose effective verbal and nonverbal techniques (e.g., voice, gestures, eye contact) for presentations.
- **Analysis and Evaluation of Oral and Media Communication 1.12.** Evaluate the clarity, quality, effectiveness, and general coherence of a speaker's important points, arguments, evidence, organization of ideas, delivery, diction, and syntax.
- **Analysis and Evaluation of Oral and Media Communication 1.13.** Analyze the types of arguments used by the speaker, including argument by causation, analogy, authority, emotion, and logic.

Speaking Applications

- **Deliver Persuasive Arguments 2.5**

a. Structure ideas and arguments in a coherent, logical fashion.
b. Use rhetorical devices to support assertions (e.g., by appeal to logic through reasoning, by appeal to emotion or ethical belief; by use of personal anecdote, case study, or analogy).
c. Clarify and defend positions with precise and relevant evidence, including facts, expert opinions, quotations, expressions of commonly accepted beliefs, and logical reasoning.
d. Anticipate and address the listener's concerns and counterarguments.

Grades 11-12

Listening and Speaking Strategies

- **Organization and Delivery of Oral Communication 1.6.** Use logical, ethical, and emotional appeals that enhance a specific tone and purpose.
- **Organization and Delivery of Oral Communication 1.8.** Use effective and interesting language, including:
  a. Informal expressions for effect
  b. Standard American English for clarity
  c. Technical language for specificity.
- *Analysis and Evaluation of Oral and Media Communications* **1.11.** Critique a speaker's diction and syntax in relation to the purpose of an oral communication and the impact the words may have on the audience.
- *Analysis and Evaluation of Oral and Media Communications* **1.12.** Identify logical fallacies used in oral addresses (e.g., attack *ad hominem,* false causality, red herring, overgeneralization, bandwagon effect).

HISTORY/SOCIAL SCIENCE

- **Principles of American Democracy 12.7.5.** Explain how public policy is formed, including the setting of the public agenda and implementation of it through regulations and executive orders.
- **Principles of Economics 12.1.3.** Identify the difference between monetary and nonmonetary incentives and how changes in incentives cause changes in behavior.

Objectives:

Students will be able to:

- Determine some of the effects of planting native or non-native plants
- Present arguments in favor of one or more viewpoints concerning land use
- Evaluate arguments

Materials:

- Handouts
  Castaways Park Background
  Castaways Park Interest Groups
  Stop-watch or clock with second-hand

Preparation:

- Make a copy for each student of the *Castaways Park Background* handout.
- Make a copy for each group of the *Castaways Park Interest Groups* handout.

Time Required:

Approximately 2 class sessions

Procedures:

Session One

1. Remind students that deciding how land should be used is not always easy, as people have different values, interests, and ideas. Explain that they are going to look at a recent land use controversy that affected Upper Newport Bay.

2. Distribute to each student a copy of the *Castaways Park Background.* Tell students that it describes a real issue in Newport Beach concerning a park that represented one of the last remaining undeveloped pieces of land adjacent to the Bay. Have students read the information.

3. Discuss the various options presented. Ask students to predict who in the community would favor each option. Have students vote on the option they support and record this as the initial tally.

4. Divide students into 10 groups. Hand out copies of *Castaways Park Interest Groups*. Assign each student group to represent one of the interest groups listed.

5. Explain that each group will present their viewpoint at a mock City Council meeting staged in the class. Tell students not only to use the information presented on the handout but also to research other points that may be relevant to their choice. Encourage students to read the information about all the interest groups—and to determine the pros and cons of each option—so that they can be prepared to counter the arguments raised by groups in favor of other options.

6. Inform students that presentations will be limited to five minutes, including a two-minute question session. Tell each group to designate spokespersons to present the group's viewpoints and to question others at the City Council meeting. Allow students time to work on their presentations. Inform students when the City Council meeting will take place.

Session Two

1. Seat the City Council Members facing the audience. Call the City Council meeting to order. Have one of the council members review the Castaways Park issue and options

2. Explain that there will be no interruptions and that question sessions will follow each presentation. Encourage students to take notes so they can present counterarguments during the question sessions.

3. Open the floor for each interest group to present. Be sure to stop presentations after three minutes and stop question sessions after two-minutes.

Follow-up:

1. Take a Council vote to see if any clear decision has been reached. Take a class-wide vote and discuss any changes from the initial tally.

2. Discuss the process.
   What challenges did they face in coming to a decision?
   Were any of the groups' arguments particularly convincing?
   What compromises can be made?

3. Discuss what has happened in Castaways Park. On September 23, 2002, the Newport Beach City Council approved Option 2 with a 4-2 vote. Meadow sedge, a hardy native, replaced the plan for wildflowers and grasses on the bluff while the remainder of the native plant palette was unchanged. There was a large community turnout at the meeting with native park supporters outnumbering others by three to one.

Extensions:

1. Collect newspaper articles concerning local water-related and land-use issues and discuss the options. Attend a city council meeting and be prepared to voice your opinion.

2. Learn more about environmental impact reports (EIRs). Obtain copies of EIRs for wetlands in your area. What concerns are addressed in these documents?

3. Research zoning laws and land use regulations in your area. Would any of the laws affect the outcome at Castaways Park?

Castaways Park Background

Castaways Park—a 17-acre area adjacent to Upper Newport Bay— was designated as a "natural park" by the City in June of 1998. A combined grant of $150,000 has been offered by the California Coastal Conservancy (CCC) to revegetate the park with native plants historic to this region, including a natural meadow with wildflowers and grasses in the central area. The grant could also be used to repair trails, put up interpretive signs and displays, and create an educational demonstration area providing information about the local wildlife, native plants, and their interactions.

This restoration plan was approved unanimously by the City Council in 2002, but before it was installed certain questions arose regarding what kind of public use could be provided at the Castaways Park site. Some interest groups proposed the City reject the plans and give up the grant money. A City Council meeting was ordered to address these concerns and to allow community members to voice their opinions on the subject. The following four options were proposed for discussion.

<u>OPTION 1</u>

Accept the grant agreement for the Revegetation Plan (1) to revegetate the Park with native plant communities, (2) to install temporary irrigation, interpretive displays, and a demonstration area to explain the species present and the wildlife supported by each plant community; and (3) to improve the existing interior trails. In this plan, the City pays only 35 percent of the total project cost, estimated at $230,000. For the next 20 years, any modifications to the agreement must be approved by the CCC, or the city must repay the grant.

<u>OPTION 2</u>

Amend the agreement to plant three-quarters of an acre with native turf that can withstand light recreational activities, such as kite flying and picnicking, better than the native grasses and wildflowers of Option 1, thus opening up the park to more recreational uses. Option 2 would cost the City an additional $25,000. A permanent irrigation system would be installed and annual maintenance efforts and costs would increase.

<u>OPTION 3</u>

Plant three acres of non-native grass that could sustain active recreation, such as ball games. This turf grass would increase the cost to the City by $80,000-$100,000 as it would require a permanent irrigation system, would need more water, and would require higher maintenance costs for mowing, irrigation, and fertilizer. There is potential for much higher public usage with Option 3 than with Options 1 or 2. Installing this non-native grass violates the CCC agreement to use only native species, so the City would have to fund the park itself and future grant opportunities might be jeopardized.

<u>OPTION 4</u>

Leave Castaways Park as it is, a mix of ruderal weeds and natives, declining the grant money. Costs to the City would be the $24,000 already spent on the project.

Castaways Park Interest Groups

Council Members
If the City rejects this grant, breaking the previous agreement, you fear that obtaining future grants for upcoming projects from the CCC and other environmental organizations may prove difficult. You are aware that other open spaces in the City are also suitable for native plantings in the future if other grants can be secured. It is important to keep your voters happy. You will have to vote on a decision by the end of the meeting, so you must be prepared to ask questions from the community representatives.

The California Coastal Conservancy (CCC)
Your Revegetation Plan would create a unique all-native park that would be a leading example to the rest of the county. A special Castaways Park Advisory Committee, consisting of representatives of the neighborhood and experts from a broad spectrum of fields, was created in order to come up with a vegetation plan that took safety, education, water conservation, recreation, esthetics, and the preservation of native wildlife into consideration. For these reasons, you feel that Option 1 is the best choice for the creation of a successful self-sustaining native park, but you are willing to accept Option 2.

Department of Water Conservation and Management (DWCM)
Southern California is a region known to experience periodic droughts. Grass lawns require large amounts of water. Since water is a limited resource, using native plants to vegetate Castaways Park will not only save money on water bills but also set a good example for water-wise gardening. Also, it is possible the runoff from irrigating grass lawns would contaminate the adjacent wetlands with fertilizers, herbicides, and pesticide residues. You support Option 1.

Fire Department
While all four options retain provisions for fire safety, you feel that Option 1 is the best, though would accept 2 or 3. Some of the non-native plants currently growing in Castaways Park catch fire easily. The fire abatement costs for periodically clearing brush from the site is $25,000 per year. The Fire Marshal provided the Castaways Advisory Committee with a list of native fire retardant plants for their Vegetation Plan. Replacing the non-native plants with coastal sage might help reduce the costs of fire abatement, and the money saved could be used elsewhere.

Homeowner's Association
You live adjacent to Castaways Park. Neighbors of nearby Bob Henry Park, which is largely a turf area designated for active recreation, have complained of trash and noise pollution due to the high number of people that come to use its grassy field. The residents of your community are concerned that a large grass area added to Castaways Park will draw a noisier and messier crowd. Furthermore, you are familiar with the drainage problems at Castaways Park, particularly near the bluff. You fear that water used in the regular irrigation of grass areas could seep underground and create dangerous instability and erosion near the bluff. You don't wish for the possibility of trash, noise, or land disturbance in your neighborhood, and support Options 1 or 2. Why replicate Bob Henry's turf park next-door?

Naturalist Volunteers
You have noticed increased wildlife visitation in areas you've helped restore in Upper Newport Bay and have a great appreciation for the knowledge you've gained about native plants. You feel it is

important to have Castaways Park become an all native park to compliment the adjacent wetlands at Upper Newport Bay. This would expand the habitat of the animals by allowing them to cross from one park to the other and utilize the resources of both. You think the general public would enjoy and benefit from the opportunity to learn plant identification, so you encourage interpretive signage at a native park. You support Option 1, but would accept the compromise of Option 2.

Local Organization of Retirees

You truly appreciate parks for both the scenery and the outdoor activity they allow. You enjoy seeing your grandson fly his kite at the park, having picnics with your friends, bird watching with the local club, and reading and snoozing in the sun. If the central meadow area is planted with just native grasses, some recreational activities may not be possible. Also you believe that native grasses are brown and ugly during the summer and that coastal sage scrub may have thorns that could poke people enjoying the meadow. You prefer Option 3.

City Recreation Department

The City has few practice fields and scheduling practice times can be difficult. The City recently created a Parks Ranger Program to police the parks because fights have occurred over who gets to use the space. You understand Castaways Park is designated for only passive recreation such as strolling, bird watching, or reading. You support Option 3, in the hopes that adding grass to Castaways Park might relieve some of the congestion at local fields.

Local Hiking Group

You enjoy hiking at parks around Newport Bay. On numerous occasions, you have observed people leaving the designated trails and entering into restricted areas. You feel that if there were more parks around the Bay where people could wander freely, they would pay greater respect to parks with restricted areas. Castaways Park should become an area where people can explore nature without worry of breaking the rules. Besides, the existing native parks currently lack enough people policing the area to stop the destructive activities occurring in fragile habitats. Why add a new park with restricted areas when other parks aren't adequately protected? You support Option 4.

Community Park Foundation

You support the local parks and believe that the rules of the CCC agreement are too strict. You feel that the City should have more control over how to use and design the park—whether planted with native or non-native plants. A 20-year commitment is too long to give up control of this prime property. The great views and location of Castaways Park give the land an estimated worth of $17 million. Why give up control of a multi-million dollar property to outside sources in order to save $150,000? You support Option 3 or 4, whatever it takes to not accept the terms of the grant.

Taking Action

In the 1970's, with approximately half of the wetland acreage in the United States lost to development, agriculture, and other land uses, the government finally began to take action to protect what remained—through federal and state legislation.

One federal law—the Clean Water Act—contains provisions (Section 404) to improve the water quality of wetlands and protect wetlands from development. Section 404 does not prohibit development in wetlands. But if properly enforced, it does provide a way to control wetland destruction and encourage more ecologically sound alternatives. In California, the California Coastal Act provides additional protection for wetlands and other sensitive habitats. Both of these laws provide opportunities for public review and comment on proposed developments.

Though these laws do provide some protection for wetlands, many people believe that more needs to be done to prevent additional wetland losses and to restore wetlands that have been dredged, drained, or polluted.

Restoration

Many of our remaining wetlands have been degraded so that they no longer support the diversity of wildlife that once existed there. These wetlands may benefit from restoration.

Can We Restore Nature?

As it applies to nature, the term "restoration" means different things to different people. To some, restoration means recreating what existed in the past. To others, it is re-establishing a portion of the values and functions of a damaged ecosystem. In many cases, complete re-creation of a pre-existing ecosystem is not feasible. Factors that restrict our ability to completely restore a degraded ecosystem include:

- human-built constraints, such as bridges, roads, upstream dams, and other developments
- our limited scientific knowledge of what it takes to successfully restore an area
- limited funds—restoration can be very expensive.

Restoration usually focuses on the whole ecosystem, not on a single species. In spite of difficulties and constraints, restoration projects strive to replicate as many of the values and functions of the original ecosystem as possible, to support multiple native species and create a healthy, self-sustaining system.

Restoring wetlands—replicating the complex physical, chemical, and biological interactions—is not quick or easy. It is a process that takes place over a long time. Restoration often requires:

- Re-establishing water flow to support wetland plant communities. This may mean redirecting a river back into the wetlands, removing dams, or dredging certain areas.

- Controlling pollution. Determining and decreasing sources of contaminants that enter the wetland can be accomplished through educating the public and developing and enforcing laws.

- Re-establishing functional habitat. This may involve removing invasive species, growing and installing native plants, and maintaining the restored habitat by weeding and watering.

- Creating habitat links so that species can breed and maintain genetic diversity. This may require bridging roads or establishing "green-ways" in order to connect existing habitats so that wildlife can travel between isolated patches.

- Long-term monitoring and adaptive management. Measuring plant survival, wildlife usage, and other wetland functions provides information on what is working and what can be improved to achieve goals. Using an adaptive management strategy enables ecologists to respond to changing conditions and needs.

Some of the goals of restoration are for the wetlands to become:

- sustainable, with vegetation maintaining and replacing itself over time, independent of human help
- resistant to invasion by non-native species
- diverse, with a range of habitats and species.

Restoring UNB

Years of rapid urban growth have seriously degraded the wetlands of Upper Newport Bay (UNB). Some existing problems include:

- water containing pesticides and heavy metals from urban runoff at levels toxic to aquatic life
- trespassers and dogs disturbing the nesting areas of the endangered Least Tern, Belding's Savannah Sparrow, and Light-footed Clapper Rail
- invasive species, which represent almost half of the plant life at UNB, displacing native communities; many plants and animals that exist nowhere else depend on UNB, but with the continued disappearance of native habitat, these species are threatened with extinction.

Recognizing that southern California's coastal wetlands are of vital ecological, hydrological, and economic significance, the California Coastal Commission selected Upper Newport Bay, the region's largest wetland, to pilot a Community-Based Restoration and Education Program. CBREP recruits volunteers from the general public and schools to restore habitat at UNB.

Program volunteers have:

- removed thousands of pounds of invasive plants
- created a native plant nursery
- planted natives that support indigenous wildlife
- monitored restoration sites for vegetation coverage and wildlife usage.

Volunteers also remove more than 15 tons of trash each year that washes into the Bay and endangers its wildlife and blemishes its beauty. Other groups working in conjunction with CBREP to restore and protect the Bay include the California Department of Fish and Game, Orange County Harbors Beaches and Parks, the City of Newport Beach, and the Newport Bay Naturalists and Friends.

Stewardship

Without help, the sensitive habitats of Upper Newport Bay—as well as other wetland areas—will continue to be threatened. Although we have halted the high rate of wetland destruction, much work remains to be done to protect and restore remaining wetlands. Everyone can help.

Environmental stewardship is an understanding that we are both caretakers of and dependent on the natural environment. Human health and well-being depend on clean water and air and on functioning ecosystems. As humans, we have the power to decide how we want to live in the world—whether we are going to exploit the environment for short-term gains or live in harmony with it. By recognizing our interdependence with the natural world, we begin to take responsibility for its future and our own.

Ultimately what is good for our natural environment is good for us as well.
We benefit in many ways from maintaining and restoring natural places like Upper Newport Bay. Besides providing flood protection and a system for filtering water, wetlands provide habitat and nurseries for plants, fish, birds, and other wildlife, and also offer important open space for people to bike, jog, kayak, or simply walk or sit and observe nature's beauty.

Each of us, as individuals and as groups, can help improve and restore our wetlands and other sensitive habitats by getting involved.

> First, learn about the importance of wetlands and other sensitive habitats, and the issues that affect these natural environments. Share your knowledge with others.
>
> Second, be active. Participate in clean-up days or restoration events. Plant natives in your backyard and enjoy the wildlife they attract. And get others involved. When people help pick up the trash that has collected downstream or keep track of the quality of the water in the Bay, they become aware of such harmful habits as littering or washing the car in their driveway.
>
> Third, participate in the decision-making process. Government officials who make decisions concerning wetlands and other sensitive habitats need to hear your views. Write letters and attend public hearings. And whenever possible, let your voice be heard by voting.

Protection and restoration of our natural environment is possible if government and the residents in the watershed work together. The value of restoration is not just its ability to transform the landscape but also its ability to educate and transform the human beings who inhabit and shape it.

Activity: Seed Experiments

Summary: Students germinate seeds, compare plant growth and health, introduce variations in soil, and gather and analyze data on optimal conditions for plant growth.

California State Content Standards

SCIENCE

Chemistry
- **Acids and Bases 5a.** Students know the observable properties of acids, bases, and salt solutions.
- **Acids and Bases 5d.** Students know how to use the pH scale to characterize acid and base solutions.

Biology/Life Sciences
- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
- **Ecology 6e.** Students know a vital part of an ecosystem is the stability of its producers and decomposers.

Investigation and Experimentation
- **1a.** Students will select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
- **1b.** Students will identify and communicate sources of unavoidable experimental error.
- **1c.** Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- **1d.** Students will formulate explanations by using logic and evidence.

MATHEMATICS

- **Probability and Statistics 6.0.** Students know the definitions of the *mean, median,* and *mode* of a distribution of data and can compute each in particular situations.

Objectives:
Students will be able to:
- Germinate seeds
- Analyze data on plant growth

Materials:
- Seeds with high germination rates; if growing plants for a restoration project, use California native plants:
  - Goldenbush – *Haplopappus venetus*
  - Bush Sunflower – *Encelia californica*
  - Sagebrush – *Artemisia californica*
- Newspaper
- Plastic wrap
- Water spray bottle
- Water
- Seeding flats
- Liners (small plant pots)
- Potting soil
- (*optional*) Seed-starter mix (may produce better germination)
- Substances to change soil conditions (not too toxic!), such as baking soda, vinegar, fertilizer, sand, salt, etc.
- Handouts
  - *Observation Worksheet* (Parts 1, 2, 3, and 4)
  - *Planting Techniques*

Preparations:
- Make a copy of the 4 parts of the *Observation Worksheet* for each student or group

Time Required:
- Three 50-minute class periods
- 5 minutes each day for 2 weeks for observing and recording

Note: The Community-based Restoration and Education Program at Upper Newport Bay may provide seeds, flats, and pots; call 949-640-0286.

Procedures:

Part I – One 50-minute class period plus 5 minutes for observation/recording each day for the next week.

1. Distribute to each student or group:
   - seeding flat
   - seed-starter mix or potting soil
   - three different kinds of seeds
   - Part 1 of the *Observation Worksheet*
2. Ask students to complete questions 1 through 3 on their worksheets:
   - the common and scientific names of the seeds
   - a description of the seeds
   - a prediction of the number of days for the seeds to germinate (to sprout)
3. Have students sow their seeds following these directions:
   - Fill a container with drainage holes to the top with seed-starter mix or potting soil; pat down lightly and uniformly.
   - Water thoroughly. After watering, the surface of the soil should still be level.
   - Broadcast the seeds evenly on the surface.
   - Sprinkle seed-starter mix or potting soil to cover the seeds to a depth equal to one or two times its smallest diameter. Seeds sown too deeply will not produce seedlings.
   - Spray the soil with water and place the container in a sheltered location out of direct sunlight.
   - Use masking tape and a marker to label the species, date, and student or group name on the container.
   - For protection and moisture retention, enclose the container in a plastic bag or piece of plastic wrap, with a sheet of newspaper on top to prevent heat build-up.
   - During the germination period (1-2 weeks), keep the surface of the soil moist. As seeds start to germinate, remove the newspaper and plastic.
4. Have students record daily observations on Part I of the *Observation Worksheet*.

Part II – One 50-minute class period plus 5 minutes for observation/recording each day for the next week.

1. Distribute to each student or group Part 2 of the *Observation Worksheet*.
2. Use the questions on the worksheet to have students compare and compile data on the germination of their seeds.
3. Explain that to demonstrate the importance of soil composition and the effects of contaminants in soils, they are going to plant their seeds in different soil mediums. Ask students what pollutants might be absorbed into soils, how long these contaminants might last, and how they might be cleaned from the soil? Have students choose the variations they will introduce.

Possibilities include:
- adding acidic or basic substances such as vinegar and baking soda to change the pH
- adding sand or salt to alter the soil composition
- using various fertilizers
- using soil from the yard
- over-watering

4. Have students transplant their seedlings following these directions:
   - When the seedlings are large enough to handle, prepare the contaminated soils and fill liners 2/3 full. Water the liners. Fill at least one liner with unaltered potting soil to act as a control. Transplant extra seedlings into potting soil to grow for restoration.
   - Lift each seedling out with a fork or knife to protect the tender roots.
   - Gently hold the seedling with roots dangling above the liner soil and sprinkle more soil around the roots until they are buried.
   - Lightly press the soil around the root crown and add more soil until the seedling is planted to the same depth as it was in the flat.
5. Distribute to each student or group Part 3 of the *Observation Worksheet*. Ask students to fill in questions 1 through 3 on their worksheets.
6. For the next week, have students monitor plant growth and health and record their observations on their worksheets.

<u>Part III</u> – One 50-minute class period.

1. Distribute to each student or group Part 4 of the *Observation Worksheet.*
2. Use the questions on the worksheet to have students compare and compile data on the growth of their plants.

<u>Follow-up:</u>

Follow the *Planting Techniques* to plant the native seedlings on the schoolgrounds or at Upper Newport Bay after the first rain of the season. (Contact UNB Restoration Project to arrange for planting.)

<u>Extension:</u>

Have students calculate the variance and the standard deviation of the time that it took for all the seeds in the classroom to germinate. Explain that variance and standard deviation are indices that statisticians use to characterize differences in a population.

x = the number of days to germination

mean = average

$$\text{Variance} = \frac{(\text{x for Seed 1} - \text{mean germination of all seeds})^2 + (\text{x for Seed 2} - \text{mean germination of all seeds})^2 + \ldots\text{etc.}}{\text{Total number of seeds}}$$

Standard Deviation = the square root of the variance

Adapted from “Seed Experiments” from *National Park Labs Curriculum*, National Park Service at the Golden Gate National Recreation Area.

Observation Worksheet

Part 1
(Answer before sowing seeds.)

1. What are the common and scientific names of your seed species?

	Seed A	**Seed B**	**Seed C**
Common Name	____________________	____________________	____________________
Scientific Name	____________________	____________________	____________________

2. Describe the condition of your seeds. What do the seeds look like? Is there any visible damage? Are the seeds robust or withered? What color are they? Can you tell by looking at them what the seed dispersal mechanism is?

Seed A ____
____

Seed B ____
____

Seed C ____
____

3. Predict the number of days it will take for your seeds to germinate.

Seed A ________ **Seed B** ________ **Seed C** ________

4. Monitor daily changes below. Note the day of seed germination.

	Date	**Time**	**Observation**
Seed A			
Seed B			
Seed C			

Observation Worksheet

Part 2

(Complete one week after sowing seeds.)

1. How long did it take for your seeds to germinate?

Seed A ________ days **Seed B** ________ days **Seed C** ________ days

2. Did your seeds take a longer or shorter time to germinate compared to other seeds in your classroom? (circle one)

Seed A	**Seed B**	**Seed C**
Longer or **Shorter**	**Longer** or **Shorter**	**Longer** or **Shorter**

3. For all the seeds in your classroom, determine the mean (average), mode (most common), and median (middle) time it took them to germinate.

Mean = **Mode =** **Median =**

---

4. What was the germination rate (percentage of seeds sown that germinated) in your classroom?

____

(number of germinated seeds ÷ total number of seeds x 100 = % germination rate)

5. Graph the time it took for the seeds to germinate.

Number of Germinated Seeds

Number of Days

6. What are some of the reasons that the seeds germinated on different days?

____

____

____

____

Observation Worksheet

Part 3
(Complete immediately after treating soil.)

1. How was your soil treated?

   Treatment 1 (T1): ______________________________

   T2: ______________________________

   T3: ______________________________

2. Measure the pH, nitrogen, phosphorous, and potassium levels of the soil and record below.

   Seed A pH _____ nitrogen _____ phosphorous _____ potassium _____

   Seed B pH _____ nitrogen _____ phosphorous _____ potassium _____

   Seed C pH _____ nitrogen _____ phosphorous _____ potassium _____

3. Predict the growth of the plants in altered soil (experimental plants) compared to the control plants.

   ____
   ____
   ____
   ____

4. Monitor daily changes below.

	Date	Time	Observation
Seed A			
Seed B			
Seed C			

Observation Worksheet

Part 4
(Complete one week after treating soil.)

1. How have your experimental plants grown in comparison with your control plants?

2. How have your plants grown in comparison with other plants in your classroom?

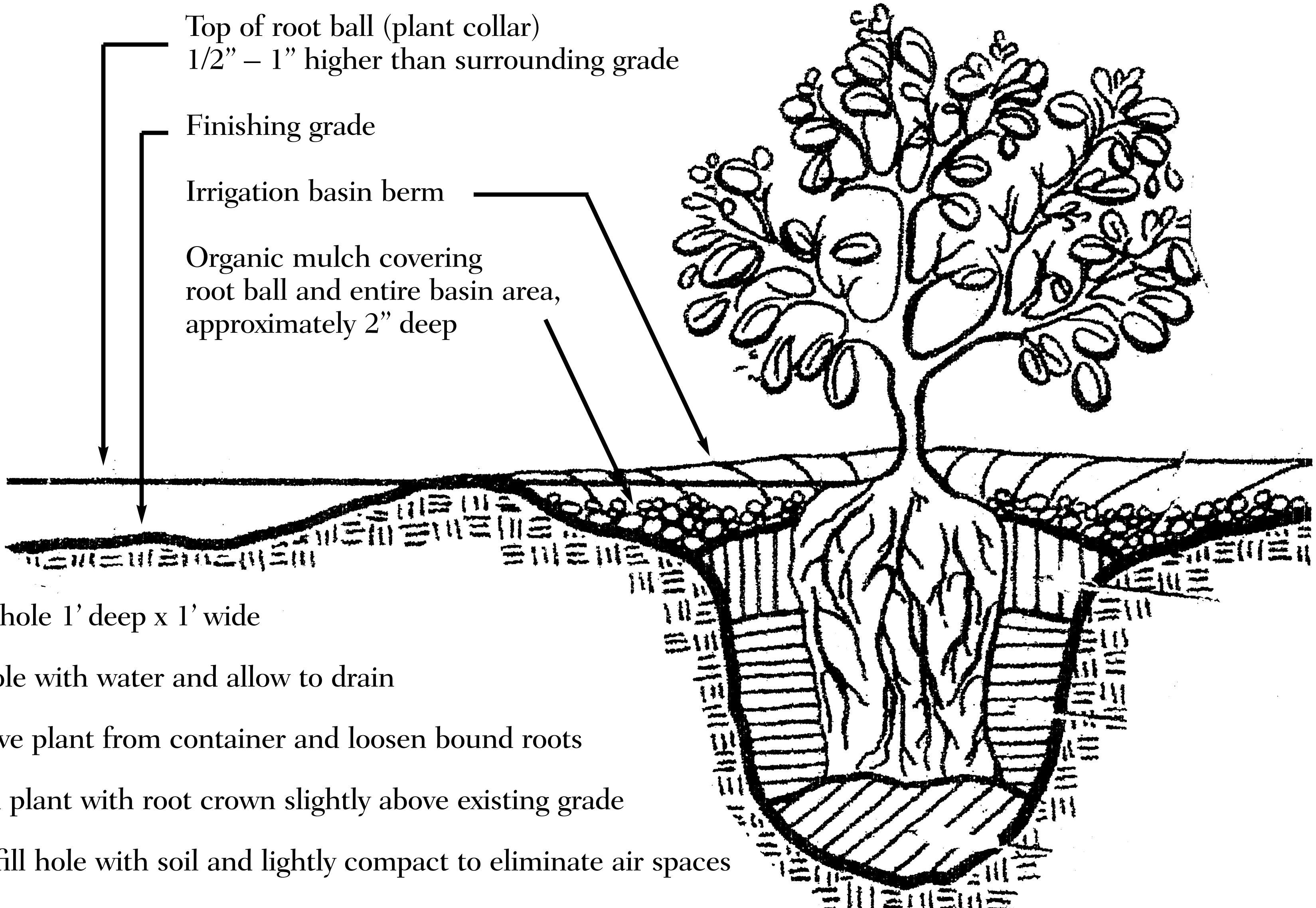
3. How does your actual plant growth compare to your predictions (Part 3)?

4. What are the most favorable soil conditions for plant growth?

5. What are the least favorable soil conditions for plant growth?

6. For each treatment, create a graph that compares plant growth and survival among species. Include all details that you feel are important. Label both axes.

7. How do contaminants in soil affect plant health?



1. Dig a hole 1’ deep x 1’ wide
2. Fill hole with water and allow to drain
3. Remove plant from container and loosen bound roots
4. Install plant with root crown slightly above existing grade
5. Back fill hole with soil and lightly compact to eliminate air spaces
6. Build an irrigation basin with a 3” high eastern berm
7. Cover basin bottom and berm with a 2” layer of mulch
8. Irrigate basin with 4 gallons of water

Activity: Plant Monitoring

(Field Study)

Summary: Students learn to compare the ecological roles of native and non-native plant species in an ecosystem and to assess the impact of removing invasive plants based on interdependencies within the system. At Upper Newport Bay, or other site, students monitor vegetation growth.

California State Content Standards

SCIENCE

Biology/Life Sciences

- **Ecology 6a.** Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
- **Ecology 6c.** Students know how fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death.
- **Ecology 6d.** Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.
- **Ecology 6e.** Students know a vital part of an ecosystem is the stability of its producers and decomposers.
- **Evolution 8b.** Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.

Investigation and Experimentation

- **1a.** Students will select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
- **1g.** Students will recognize the usefulness and limitations of models and theories as scientific representations of reality.
- **1j.** Students will recognize the issues of statistical variability and the need for controlled tests.
- **1k.** Students will recognize the cumulative nature of scientific evidence.

ENGLISH-LANGUAGE ARTS

Grades 9-10

Speaking Applications

- **Deliver Expository Presentations 2.2**

b. Convey information and ideas from primary and secondary sources accurately and coherently.
c. Make distinctions between the relative value and significance of specific data, facts, and ideas.
f. Use technical terms and notations accurately.

- **Deliver Descriptive Presentations 2.6c.** Use effective, factual descriptions of appearance, concrete images, shifting perspectives and vantage points, and sensory details.

Grades 11-12

Listening and Speaking Strategies

- **Organization and Delivery of Oral Communication 1.8.** Use effective and interesting language, including:
  a. Informal expressions for effect
  b. Standard American English for clarity
  c. Technical language for specificity.

MATHEMATICS

- **Probability and Statistics 8.0.** Students organize and describe distributions of data by using a number of different methods, including frequency tables, histograms, standard line and bar graphs, stem-and-leaf displays, scatterplots, and box-and-whisker plots.

Objectives:

Students will be able to:

- Identify wetland plants
- Use quadrats to inventory plants
- Monitor a site to determine ecosystem health

Materials:

- Cones or flags to mark off field study area (if needed)
- Field Guide for plants (see www.newportbay.org/plants)
- *(optional)* Camera and compass for photo-monitoring log
- Handouts
  - *Plant Monitoring Log*
  - *Percent Coverage Data*

For each group:

- Hula Hoop® or meter-square quadrat (can be made from PVC piping and elbows or meter sticks and string)
- Clip board and pen

Preparations:

- Contact field study site to arrange a visit. (See Apendix D. For UNB call 949-640-0286.)
- Find out what materials will be available on site.
- Make a copy of the *Plant Monitoring Log* and *Percent Coverage Data* handouts for each group.

Time Required:

- 50 minute class session
- Approximately 1-1/2 hours in the field to inventory plants and discuss findings

Note: Plants are easiest to identify during the growing season, March-June.

Procedures:

Part I – In class, prior to field study.

A. Demonstrate the concept of interdependence *(optional)*

1. Have students stand in a circle. Ask each student to name a specific part of the wetland ecosystem, either biotic (living) or abiotic (non-living)—for example: cordgrass, water, plankton, sun, killifish, clam, Brown Pelican, Light-footed Clapper Rail, cattail, soil, etc. Be sure all major areas of the ecosystem are represented, including the primary energy source—the sun.

2. Ask every other student in the circle to turn and face the outside. (Remove one student if there is an odd number.) Ask students to either hold hands or link elbows and then to lean back with their arms in front of them until they all find balance. Explain that they are demonstrating the delicate balance in any ecosystem.
   (Note: If students are reluctant to perform this activity, simply have various students state how their part of the wetland ecosystem is related to other parts.)

3. Explain you are going to act as an invasive plant that disrupts the interdependencies of the ecosystem. Attempt to break the balance of the ecosystem by pulling some students' hands or arms apart. Point out that though some sections stick together, the overall balance of the structure is broken. Ask students which links they think would break first in the ecosystem?

B. Identify invasive species

1. Divide the class into groups and assign one (or more, depending on number of groups) of the following plants to each group:

    Non-native
    - Mustard, *Brassica nigra*
    - Star Thistle, *Centaurea melitensis*
    - Ice Plant, *Gasoul crystallinum*
    - Lollypop Tree, *Myoporum laetum*
    - Giant Reed, *Arundo donax*
    - Brazilian Pepper Tree, *Schinus molle*

    Native
    - Coastal Buckwheat, *Eriogonum fasciculatum*
    - California Sagebrush, *Artemisia californica*
    - Pickleweed, *Salicornia virginica*
    - Saltgrass, *Distichlis spicata*
    - Cordgrass, *Spartina foliosa*
    - Mulefat, *Baccharis glutinosa*

2. Have each group do some research and prepare a brief report and presentation on their plant species. In their presentations, be sure students address:
    - Is the plant native or non-native?
    - If non-native, where did it come from?
    - If non-native, how does it affect the ecosystem?
    - What might be the effects if it disappears?
    - Should the plant be removed?
    - If native, what role does it play within its habitat?
    - What characteristics does the plant have that allow it to survive within its specific habitat?

Part II – Field study, at Upper Newport Bay or other natural site

A. Inventory species

1. Remind students that plants provide the basis of health in a wetland. Explain that a variety or high diversity of plant species, especially native species, usually indicates a balanced ecosystem.

2. Ask students how they would study plant populations in a site. Tell students that scientists often study small sample plots—quadrats—within a site and then use this information to make generalizations about the larger study area. Explain that a quadrat is normally a one square meter area randomly selected in the site and analyzed to quantify the density and percent cover of species within the site. Tell students that they are going to use a hoop as their quadrat.

3. Along with site staff, determine the area to be inventoried and, if necessary, mark the area with flags or cones. Choose an area with easy access that will not be harmed by foot traffic. Point out the area to students and tell them that each group will sample a different part of the site. Caution students to tread lightly as they work.

4. Divide students into groups and distribute a clipboard, pen, and *Plant Monitoring Log* to each group. Before they begin, have students quietly observe their surroundings and note their observations on their *Plant Monitoring Log*.

5. Have each group randomly toss their hoop, and then count and identify plants that are within the hoop. Have students fill in their *Plant Monitoring Logs* as they work. Tell students that if they cannot identify a species, just to give it a descriptive name.

B. Discuss plant inventory

After groups have inventoried their quadrats, bring the groups together to discuss what they found. Use the following questions to generate a discussion:

1. How many total species were found?

2. What percentage of plants is native and what percentage non-native?

3. What are the five most common plants? Are they native or non-native?

4. Were there any monocultures (only one species within a quadrat) sampled?

5. What is the average percent of plant coverage?

6. What insects and other animals were identified?

7. Is there a relation between the plant coverage and the number of animals observed?

8. Do you think the area the class sampled is a good representation of the entire site? If not, by how much would you increase the sample size to achieve a good representation? How frequently would you collect data?

Follow-up:

1. Work with staff at the site to have students remove invasive plants. Use the following questions to discuss the process:

a. What are the interactions between the non-native plants and the native plants?
(The non-native plants often out-compete the native plants, limit their growth, and sometimes kill them by altering soil chemistry and sequestering water, space, light, or nutrients.)

b. What do you predict would happen to this ecosystem if we ignored the non-native plants?

c. Will this ecosystem have increased ecological function if the non-native plants are removed? How long do you think ecosystem recovery might take?
(*Removing plants disturbs the soil, and there is likely a large non-native seed bank waiting to germinate.*)

d. Besides non-native species introductions, what other disturbances could affect ecosystem balance?
(Disturbances may be natural or anthropogenic: fire, flood, drought, grazing, dredging, etc.)

2. Back in class, analyze and display the data collected. Tell students that the data they collect could be a valuable addition to a long-term study of the site.

a. Have students create a visual representation of the species data collected within the different quadrats, showing the number and type of species. Have students select an appropriate method for displaying the data, such as a frequency table, histogram, etc.

b. Have students complete the *Percent Coverage Data* sheet and use the information to create a visual representation of the percentage of native, non-native, and bare ground at the site. Have students select an appropriate method for displaying the data, such as a pie chart or graph.

Extensions

1. Have students photo-monitor the site. Establish specific points from which to photograph the site. Use a compass to determine the direction of the photograph. Record information on the direction, the date, the time of day, and the weather. Compile the photographs, records, *Plant Monitoring Log,* and *Percent Coverage Data* in a binder. Have students keep up the photo-monitoring book from season to season, year to year, noting changes in the site and positive and negative trends.

2. On a world map, have students indicate where the non-native plants in Upper Newport Bay originated. What is the climate in these areas? How did the plants get to California?

Adapted from "Invasive Plant Removal & Monitoring" from *National Park Labs Curriculum*, by National Park Service at the Golden Gate National Recreation Area

Plant Monitoring Log

Date:____________________ Data Collectors: ______________________________________

____

Site Location: ____

Site Size: ____

Weather: ____

1. Observations before analyzing quadrat:

2. Species identification (list all species within the quadrat):
   Note: When estimating percentages, first visualize the quadrat divided into quarters (25%), then record the average percentage estimated by two or more group members.

	native	or	invasive	% of quadrat
______________________________	[ ]		[ ]	________
______________________________	[ ]		[ ]	________
______________________________	[ ]		[ ]	________
______________________________	[ ]		[ ]	________
______________________________	[ ]		[ ]	________
______________________________	[ ]		[ ]	________

3. Number of species within quadrat:
   Native ____________________
   Non-native ________________
   Total _____________________

4. Percent coverage of quadrat:
   Native ____________________
   Non-native ________________
   Bare ground _______________

5. Evidence of insects and animals identified in quadrat:

	number
______________________________	______
______________________________	______
______________________________	______

Percent Coverage Data

Date: ______________________________

Site Location: ______________________________

1. Total number of quadrat samples: ______________________________

2. Total number of species found: ______________________________

3. Average number of species found in each quadrat: ______________________________
   Average = total number of species found / number of quadrats

4. Total number of native species: ______________________________

5. Percent coverage of native species: ______________________________
   Percent coverage = average % covered by native species / total number of samples

6. Total number of non-native species: ______________________________

7. Percent coverage of non-native species: ______________________________

8. Percent coverage of bare ground: ______________________________

Activity: Wetland Tradeoffs

Summary: This activity highlights the tradeoffs in wetlands management decisions. Students review the benefits of wetlands, then debate the tradeoffs in a local wetland issue.

California State Content Standards

SCIENCE

Biology/Life Sciences

- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

ENGLISH-LANGUAGE ARTS

Grades 9-10

Reading Comprehension

- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.3.** Generate relevant questions about readings on issues that can be researched.
- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.5.** Extend ideas presented in primary or secondary sources through original analysis, evaluation, and elaboration.
- **Expository Critique 2.8.** Evaluate the credibility of an author's argument or defense of a claim by critiquing the relationship between generalizations and evidence, the comprehensiveness of evidence, and the way in which the author's intent affects the structure and tone of the text (e.g., in professional journals, editorials, political speeches, primary source material).

Writing Strategies

- **Research and Technology 1.3.** Use clear research questions and suitable research methods (e.g., library, electronic media, personal interview) to elicit and present evidence from primary and secondary sources.
- **Research and Technology 1.5.** Synthesize information from multiple sources and identify complexities and discrepancies in the information and the different perspectives found in each medium (e.g., almanacs, microfiche, news sources, in-depth field studies, speeches, journals, technical documents).

Listening and Speaking Strategies

- **Organization and Delivery of Oral Communication 1.3.** Choose logical patterns of organization (e.g., chronological, topical, cause and effect) to inform and to persuade, by soliciting agreement or action, or to unite audiences behind a common belief or cause.
- **Organization and Delivery of Oral Communication 1.6.** Present and advance a clear thesis statement and choose appropriate types of proof (e.g., statistics, testimony, specific instances) that meet standard tests for evidence, including credibility, validity, and relevance.
- **Organization and Delivery of Oral Communication 1.8.** Produce concise notes for extemporaneous delivery.

Speaking Applications

- **Deliver Persuasive Arguments 2.5**

a. Structure ideas and arguments in a coherent, logical fashion.
b. Use rhetorical devices to support assertions (e.g., by appeal to logic through reasoning, by appeal to emotion or ethical belief; by use of personal anecdote, case study, or analogy).
c. Clarify and defend positions with precise and relevant evidence, including facts, expert opinions, quotations, expressions of commonly accepted beliefs, and logical reasoning.
d. Anticipate and address the listener's concerns and counterarguments.

Adapted from "Wetland Tradeoffs" from *WOW! The Wonders of Wetlands*, co-published by International Project WET and Environmental Concern

Grades 11-12

Reading Comprehension

- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.3.** Verify and clarify facts presented in other types of expository texts by using a variety of consumer, workplace, and public documents.
- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.4.** Make warranted and reasonable assertions about the author's arguments by using elements of the text to defend and clarify interpretations.
- **Comprehension and Analysis of Grade-Level-Appropriate Text 2.5.** Analyze an author's implicit and explicit philosophical assumptions and beliefs about a subject.
- **Expository Critique 2.6.** Critique the power, validity, and the truthfulness of arguments set forth in public documents; their appeal to both friendly and hostile audiences; and the extent to which the arguments anticipate and address reader concerns and counterclaims (e.g., appeal to reason, to authority, to pathos and emotion).

Listening and Speaking Strategies

- **Comprehension 1.2.** Analyze the impact of the media on the democratic process (e.g., exerting influence on elections, creating images of leaders, shaping attitudes) at the local, state, and national levels.
- **Comprehension 1.3.** Interpret and evaluate the various ways in which events are presented and information is communicated by visual image makers (e.g., graphic artists, documentary filmmakers, illustrators, new photographers).
- **Organization and Delivery of Oral Communication 1.6.** Use logical, ethical, and emotional appeals that enhance a specific tone and purpose.
- **Organization and Delivery of Oral Communication 1.8.** Use effective and interesting language, including:
  a. Informal expressions for effect
  b. Standard American English for clarity
  c. Technical language for specificity.

HISTORY/SOCIAL SCIENCE

- **Principles of American Democracy 12.7.5.** Explain how public policy is formed, including the setting of the public agenda and implementation of it through regulations and executive orders.
- **Principles of Economics 12.1.1.** Examine the causal relationship between scarcity and the need for choices.
- **Principles of Economics 12.1.3.** Identify the difference between monetary and nonmonetary incentives and how changes in incentives cause changes in behavior.
- **Principles of Economics 12.1.4.** Evaluate the role of private property as an incentive in conserving and improving scarce resources, including renewable and nonrenewable natural resources.

Objectives:

Students will be able to:

- Identify the benefits of wetlands
- Compare economic, social, and environmental tradeoffs in various wetland conservation and development decisions

Materials:

- Current reference materials that identify various viewpoints about wetland issues
- Handouts
  - *Tradeoffs Analyzer* (sample)
  - *Tradeoffs Analyzer* (blank)

Preparations:

- Bring in articles from local newspapers or magazines (or from the Internet) concerning wetlands *(e.g., dredging, invasive plant removal, herbicide-use, soft bottom channels, natural treatment systems)*
- Research current laws that affect development in wetlands (e.g., Clean Water Act, Coastal Act)
- Make a transparency of the sample *Tradeoffs Analyzer*
- Make a copy for each group of the blank *Tradeoffs Analyzer*

Time Required:

- Approximately 1 hour
  (more if students do research)

Procedures:

1. To review the importance of wetlands and to introduce varying viewpoints, ask students the following questions:

   a. Why are wetlands valuable? (**Note:** List benefits on the chalkboard.)
      - *Wetlands filter runoff, thus improving water quality.*
      - *Wetlands provide habitat and rest-stops for migratory birds.*
      - *Wetlands sustain biodiversity by supporting threatened and endangered species.*
      - *Wetlands are feeding, breeding, and nursery grounds for many animals.*
      - *Wetlands provide recreation—hiking, biking, kayaking, bird watching.*
      - *In some areas, wetlands recharge groundwater.*
      - *Wetlands protect against flood damage by storing and slowing peak flows of water.)*

   b. Why would people want to build houses or other buildings on or near wetlands?
   (People often like waterfront homes and offices. If people don't value the benefits that wetlands provide, they may want the land used in a way that is more financially beneficial to them in the short term. For example, the flat, undeveloped land with low-growing vegetation is advantageous for airports; the productive soil is beneficial for agriculture.)

   c. Why would people want to protect wetlands?
   (People may value wetlands for aesthetic beauty, for recreation, for wildlife habitat, for clean water at the beach, for the economic benefits of tourism or commercial fisheries. Some people may have only one reason; other people may value all the benefits of wetlands.)

   d. What might Upper Newport Bay look like today if citizens had not fought for its protection in the 1960s?
   (The Robinsons and other concerned citizens formed the Friends of Newport Bay in 1967, leading tours around the Bay in order to educate others about the Bay's ecological significance as well as opposing development plans, such as the Irvine Company's proposal to build hotels and marinas along the shoreline in 1969.)

2. Have students review the wetlands reference materials. Ask students what controversies they identify in the materials. Discuss and record them on the board.

3. Ask students to think of any controversies as "problems" rather than "issues." Use as an example a newspaper headline that states: "Developer Seeks Permit to Fill Wetlands for Subdivision." Explain that the "issue"— to develop or not to develop — divides people, but that a problem-solving approach will ask, "Are there alternative plans for protecting the wetland?" or "Are there alternate sites to build the subdivision?" or "Can we assure jobs and housing and still protect the environment in this case?" Ask students to identify some of the problems associated with the controversies listed on the board.

4. Have students choose a particular controversy. Ask them to:

   - describe the cause of the problem, determining if it was a natural occurrence, human-made, or a combination of the two.
   - identify the major players in the controversy and determine if others will be affected by the outcome.
   - compare the values and needs each of the players brings to the negotiating process.

5. Write a brief description of the problem in the center of the board and draw a box around it.

6. Brainstorm potential solutions to the problem. Write the proposed solutions on the board surrounding the problem description. Circle each solution.

7. Explain to students that in order to evaluate each solution, they need to determine the pros and cons. Project the overhead of the sample *Tradeoffs Analyzer*. Briefly discuss with students the problem (community flooding), the potential solutions, and the pros and cons of each solution. Ask students what solution they think is the best and why.

8. Distribute a blank *Tradeoffs Analyzer* to each student group. Ask each group to analyze the problem on the board by listing the pros and cons of the potential solutions. (If many solutions are listed, have the class choose the top four.) Encourage students to consider economic and environmental factors, including:
   - costs
   - time
   - resources
   - ecological balance
   - jobs
   - wildlife habitat
   - historic perspectives
   - people affected
   - long-term consequences
   - public policy

   (Note: If the reference materials do not provide enough information, give students time to do additional research.)

9. Have groups share their analyses, discussing any questions and debating any disagreements that arise. Create a master *Tradeoff Analyzer* on the board.

10. Ask students to rank the solutions and explain their reasons for the preferred order. Discuss the results:
    - Does the ranking reflect personal values?
    - Did they arrive at a viable solution?
    - Did the solution involve any negotiation or compromise?

Follow-Up

Have students research the consequences of their proposed solution. If students still believe that they have a viable solution and if the problem is currently being addressed in your area, have students write advocacy statements and send them to the players involved.

Extensions

1. Organize class debates on a variety of wetland issues and problems. Scenarios might include:
   - filling in and developing a wetland site
   - creating a wetland nature preserve in an area pressured by an expanding population
   - dredging a wetland to remove the sediment
   - removing an invasive plant that is aesthetically pleasing

2. Have students read newspaper accounts of a wetland controversy and analyze which arguments are based on opinions versus facts.

3. Have interested students attend and participate in public discussions of wetland issues. Ask them to report back to class.

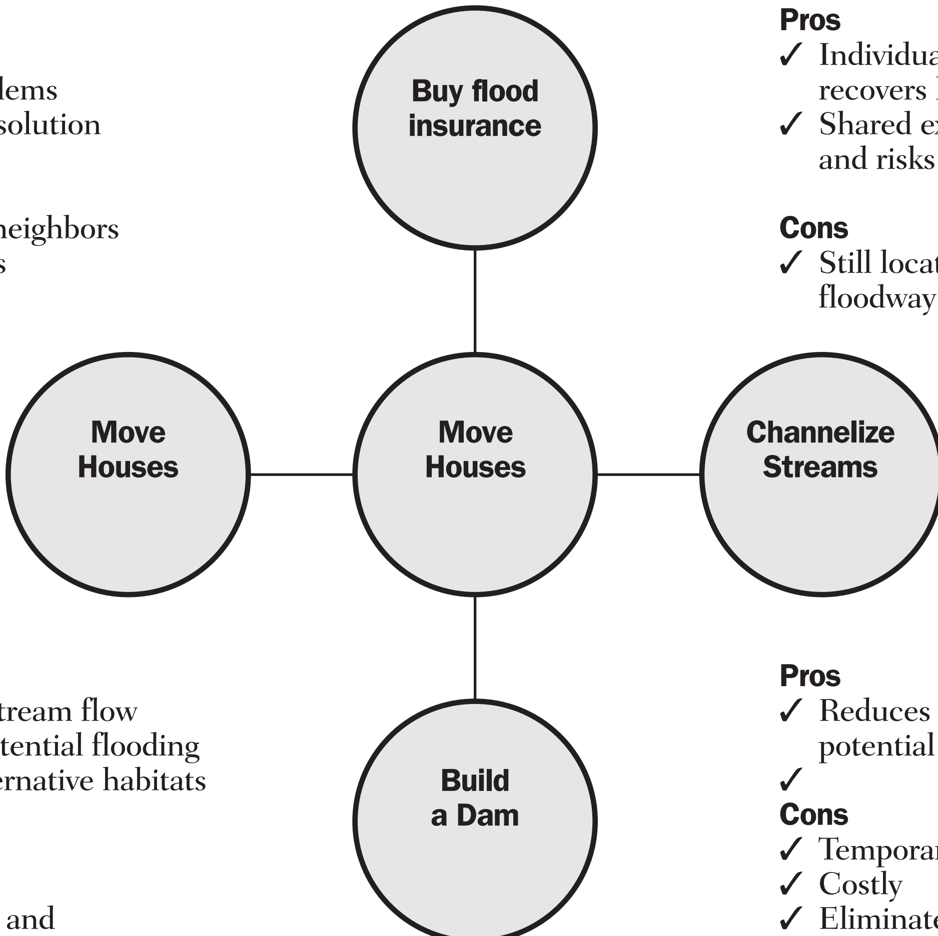
4. Tell students that sending Letters to the Editor is a great way to keep editors aware that many readers are concerned about wetlands, and it means newspapers are more likely to publish stories on the topics. Point out that published letters keep decision-makers aware of citizens' concerns and help to shape their opinions on the issue. Have students write letters to the editor. Tell them that it is best to limit yourself to 150 words or less, and remind them to include their name, home address, and daytime phone for verification.

   LA Times: letters@latimes.com, fax to 213-237-7679
   Orange County Register: letters@ocregister.com, fax to 714-796-3657

Adapted from "Wetland Tradeoffs" from *WOW! The Wonders of Wetlands*, co-published by International Project WET and Environmental Concern

Tradeoffs Analyzer

(sample)



Pros
- ✓ Eliminate future problems
- ✓ Long-term solution

Cons
- ✓ Impact on neighbors and families

Pros
- ✓ Individual or Business recovers losers
- ✓ Shared expenses and risks

Cons
- ✓ Still located on floodway

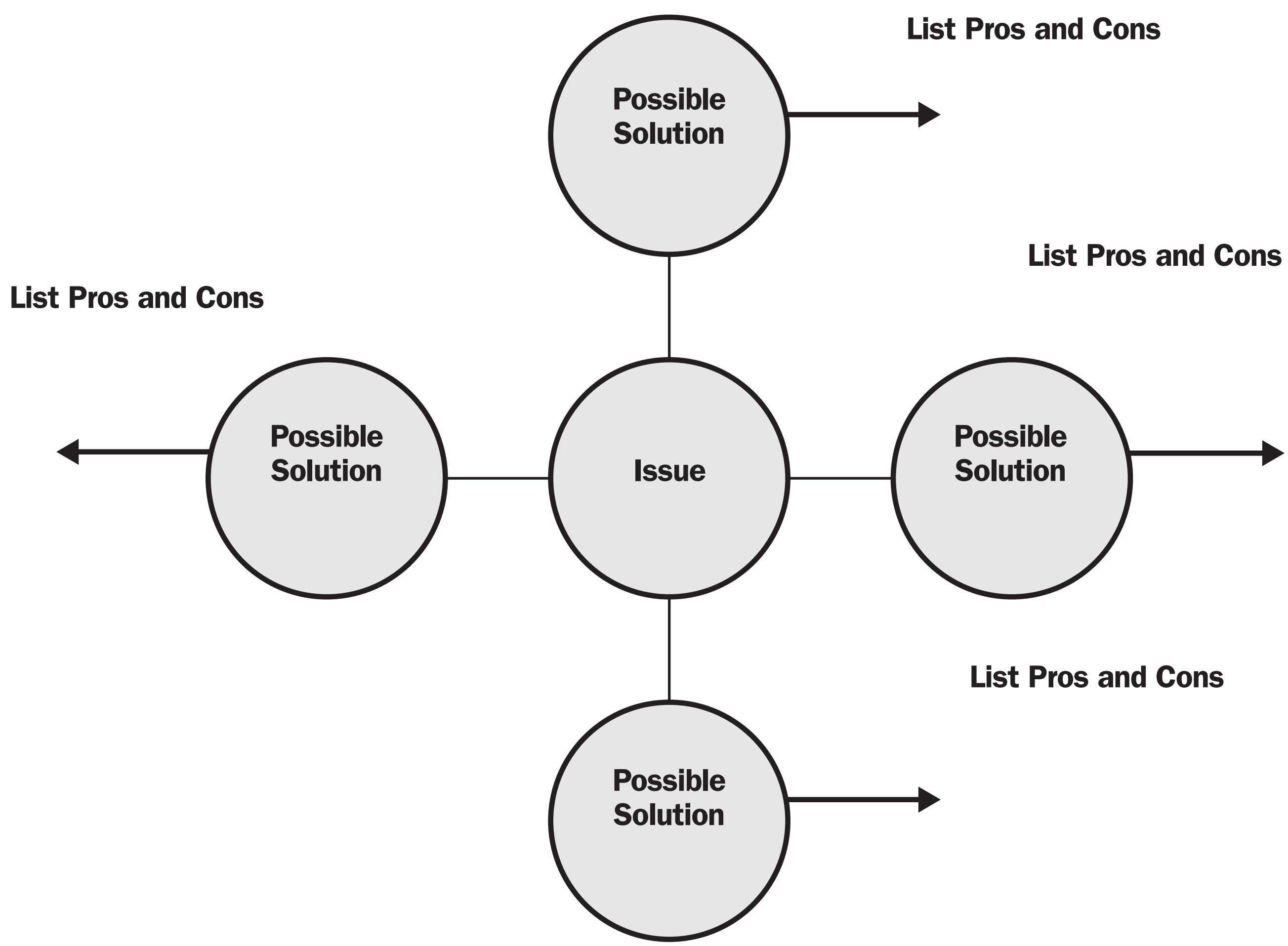
Pros
- ✓ Regulates stream flow
- ✓ Reduces potential flooding
- ✓ Creates alternative habitats for wildlife

Cons
- ✓ Loss of fish and wildlife habitat
- ✓ Alters drainage patterns
- ✓ Costly

Pros
- ✓ Reduces flood potential
- ✓

Cons
- ✓ Temporary solution
- ✓ Costly
- ✓ Eliminates habitat
- ✓ Increases sediment
- ✓ Alters drainage patterns

Tradeoffs Analyzer



Activity: Stewardship

Summary: Students learn how they can contribute to wetland preservation and restoration through stewardship.

California State Content Standards

SCIENCE

Biology/Life Sciences
- **Ecology 6a.** Students know biodiversity is the sum total of different kinds of organisms and is affected by alterations of habitats.
- **Ecology 6b.** Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

ENGLISH-LANGUAGE ARTS

Grades 9-10

Writing Strategies
- **Organization and Focus 1.1.** Prepare a bibliography of reference materials for a report using a variety of consumer, workplace, and public documents.

Writing Applications
- **Expository Compositions 2.3**

b. Convey information and ideas from primary and secondary sources accurately and coherently.
c. Make distinctions between the relative value and significance of specific data, facts, and ideas.
d. Include visual aids by employing appropriate technology to organize and record information on charts, maps, and graphs.
e. Anticipate and address readers' potential misunderstandings, biases, and expectations.
f. Use technical terms and notations accurately.

Grades 11-12

Reading Comprehension
- **Structural Features of Informational Materials 2.1.** Analyze both the features and the rhetorical devices of different types of public documents (e.g., policy statements, speeches, debates, platforms) and the way in which authors use those features and devices.

Writing Strategies
- **Organization and Focus 1.3.** Structure ideas and arguments in a sustained, persuasive, and sophisticated way and support them with precise and relevant examples.
- **Organization and Focus 1.4.** Enhance meaning by employing rhetorical devices, including the extended use of parallelism, repetition, and analogy; the incorporation of visual aids (e.g., graphs, tables, pictures); and the issuance of a call for action.

HISTORY/SOCIAL SCIENCE

- **Principles of American Democracy 12.7.5.** Explain how public policy is formed, including the setting of the public agenda and implementation of it through regulations and executive orders.
- **Principles of Economics 12.1.3.** Identify the difference between monetary and nonmonetary incentives and how changes in incentives cause changes in behavior.

Objectives:
Students will be able to:
- Participate in projects to improve wetlands
- Become aware of citizens' roles as stewards

Materials:
- Depends upon activities selected

Preparations:
- Depends upon activities selected

Time Required:
- Depends upon activities selected

Procedures:

1. Ask students what kinds of decisions they make as a group *(e.g., where to go for lunch or what movie to see)*. Then ask how the group reaches a decision.

2. Tell students that every group decision is, in some way, a demonstration of small-scale politics. Explain that the debate, discussion, lobbying, and informal voting that they use in everyday decisions can also be useful in community and national political action.

3. Ask students how certain school policies were established (e.g., dress code, lunch rules, role of student council). Ask how they would go about having a policy reviewed or changed.

4. Tell students that wetland stewardship is often in the spotlight of the political process and that students can participate more significantly than they may suspect. Explain that through becoming aware, participating in local government, being involved in the community, teaching others, and setting good examples, they can have an impact on issues important to them. For example, the Smoke-Free Beaches campaign started by high school students in Solana Beach has spread across the state, including several beaches in Orange County that have accepted a ban on smoking.

5. Review the following activities with students and have them get involved.
   Visit www.coastforyou.org for more suggestions and to take the "Coastal Stewardship Pledge."

Follow-up

Have students keep progress reports of their projects and eventually write final summary reports addressing what they did, how well it worked, what they would do differently next time, and what recommendations they would make to someone taking on a similar project.

Extensions

1. Set up committees of students to follow several local issues and make periodic reports to the class.

2. If students participated in restoration projects, have them monitor the site for maintenance needs and for future projects.

3. Have students write letters to newspapers and policy makers expressing their views on local wetlands issues.

Projects and Activities

Restore Habitat

Volunteer to help restore your local wetland or school grounds by removing invasive plants and planting natives. Become part of the ROOTS (**R***estoration* **O***utreach* **O***pportunity* **T***eamwork* **S***tewardship*) team that meets on the fourth Saturday of every month. Call (949) 640-0286 for details.

Volunteer with a Local Environmental Group

Most wetlands have one or more environmental groups dedicated to preservation and restoration. Contact these groups and volunteer to help. (See Appendix C for ideas.)

Get the Facts

If you want something done about the condition of wetlands in your community, you'll have to be well-informed. Before you begin, do your homework. Here's what you need to know:

- Why are these wetlands important or valuable to people? To wildlife?
- What (or who) is threatening the wetlands?
- Are wetlands protected? Know the law.
- Who's in charge of protecting wetlands in your state and community?
- What are local politicians' views on the environment?

Participate in Local Government

Keep informed of the environmental issues in your area. Are wetlands getting the attention they deserve? What does the planning and zoning office have in store for the wetlands in your area? If you disagree with the actions of these offices, say so! Watch the news for public hearings on development projects that may affect your community. Inform your neighbors of the problem. Write a petition stating your views, get as many signatures as you can, then take the petition to the hearing and present your case.

Start a Club

Start a campaign in your school or neighborhood to let people know about wetlands and why they are valuable. Think of a catchy slogan or a phrase that's easy to remember. Make colorful posters; create brochures or buttons; put an ad in your school or community newspaper or newsletter. Let people know how they can help conserve and protect wetlands.

Be a Role Model for Younger Kids

Help younger kids learn about wetlands and responsibility. Take kids fishing, bird-watching, or hiking and use the time to teach them about the importance of wetlands and respect for nature. Make a presentation about wetlands, such as a puppet show or play, or create songs. Volunteer to help with local schools' outdoor lessons or field trips for younger students.

Participate in Coastal Clean-up Events

Find out when coastal clean-ups are scheduled in your area (*www.coastforyou.org* or 800-Coast-4U) and get a group together to participate, or just go on your own to meet new people and help clean up the beach. (Remember not to pick-up organic debris like driftwood or kelp as these items are important players in beach ecology.)

Organize a Clean-up Day

Hold a clean-up day in your community. Organize a committee to help you plan the day. Advertise the clean-up well in advance and let people know what to bring (e.g., gloves, trash bags, wheelbarrows). Ask local stores for donations of snacks or other supplies. Combine the clean-up with something fun and educational, such as a picnic, canoeing, hiking, or a nature presentation. Circulate press releases about the entire event to broaden public awareness.

Start a Neighborhood Recycling Program

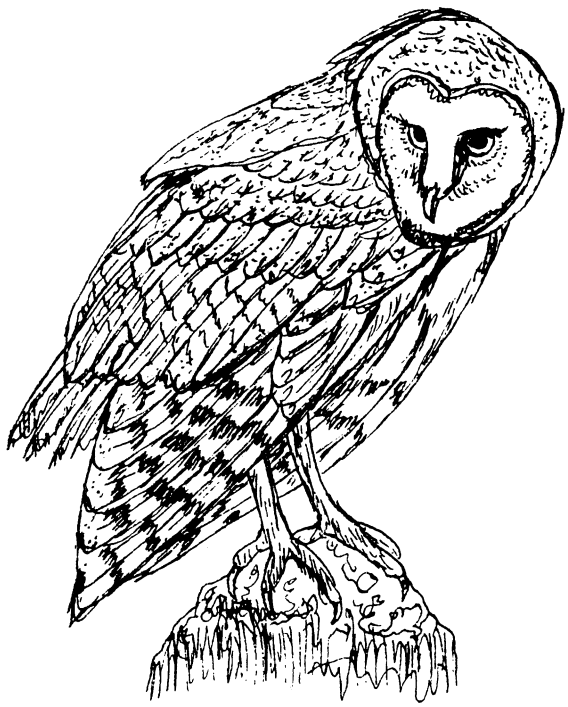
Recycling programs help keep litter down and reduce the need for landfill space. Call your city's department of public works or search online for ideas to set up neighborhood recycling. If a program already exists, encourage more people to recycle, or offer to take their materials to the collection center for them. Green waste can also be recycled; find out what composting programs your community offers.

Plant a School Garden

Work with other students and your school's administration to establish a garden on your school grounds. Types of native plant gardens suitable for schools include: container gardens, raised beds, borders along sidewalks, specialty gardens designed to attract butterflies or birds, or to be edible, or to represent plants used by California Indian tribes. Get permission for the location of the garden and the use of the school's water; request tools and plants from local stores or residents; and create a maintenance schedule. Make your garden pesticide-free and "water-wise"! Native plants may be purchased at Tree of Life Nursery—(949) 728-0685. Visit the School Gardens webpage of the California Integrated Waste Management Board at *www.ciwmb.ca.gov/Schools/WasteReduce/Food/SchoolGarden.htm*. The California Native Plant Society has published a guide titled *Southern California Native Plants for School Gardens* by Betsey Landis—(310) 472-0624.

Perform an Environmental Audit of Your School

Make a detailed study of your school's environmental impact, looking at the water and energy consumed and the waste and pollution created. Create a report for your school administration and suggest ways that the school could improve. The Natural Resources Defense Council has an interactive website that can help you learn about environmental problems and solutions at your school, *www.nrdc.org/greensquad*. Check out the Center for Environmental Education's School Sustainability Guidelines for sample audit forms, *greenschools.schoolsgogreen.org/green/GREEN_Sustain*. Read Youth for Environmental Sanity's "Green Schools Energy Project" manual, *www.yesworld.org/info/GreenSchoolsManual.pdf*, for an example of how some students helped their school become more energy efficient and save money in the process.



APPENDIX

Common Name:
ARROYO WILLOW

Scientific Name:
Salix lasiolepis

Size: between 6 and 30 feet tall

Status:	Habitat:	Trophic Level:
Native	Riparian	Producer

Features: The arroyo willow is a shrub or small tree with drooping branches, which are yellowish to red. Its slender, dark green leaves are two to five inches long. Its flowers grow in clusters, called catkins, and appear in the early spring before the leaves grow. Galls often appear on leaves as red bumps, caused by the sawfly, who lays eggs in the leaf tissue.

Facts: Willows will grow only where there is water. Their deep roots hold in soil and water, thereby reducing erosion. These native trees provide shade, shelter, and food for a variety of animals and plants, including the endangered bird Least Bell's Vireo. Willow bark contains salicylic acid, which is the main ingredient of aspirin. Native Americans used willow branches as arrow shafts and for house frames.

Common Name:
CALIFORNIA BUCKWHEAT

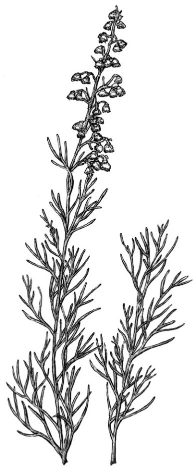
Scientific Name:
Eriogonum fasciculatum

Size:
3 feet high, 6 feet wide

Status:	Habitat:	Trophic Level:
Native	Upland	Producer

Features: California buckwheat is a low-spreading shrub that displays large clumps of white flowers that develop into cinnamon colored seed heads during summer. The small, narrow, leathery leaves are in bundles all along the stems.

Facts: California buckwheat is an important plant in the coastal sage scrub community. The flowers, leaves, and seeds are food sources for smaller animals—such as birds, lizards, mice, and butterflies. It is a favorite of bees and makes an exceptionally fine honey. American Indians used California buckwheat for medicinal purposes—to relieve headaches and stomach trouble—and for food. Have you heard of "buckwheat pancakes"?



Status:	Habitat:	Trophic Level:
Native	Upland	Producer

Features: The California sagebrush is a shrub with a woody base and soft, gray-green, needle-like leaves that grow in clusters along the stem. The leaves have a very distinctive fragrance.

Facts: California sagebrush, one of the dominant plants in a coastal sage scrub community, occurs throughout Southern California. It provides important habitat for animals that use its aromatic smell to mask their scent from predators. The leaves can be used for seasoning many foods, from tea to stew. American Indians used the plant to treat colds, stomach disorders, and bronchial problems, among other ailments.

Common Name:
CALIFORNIA SAGEBRUSH
COASTAL SAGEBRUSH

Scientific Name:
Artemisia californica

Size:
between 2 and 5 feet tall

Status:	Habitat:	Trophic Level:
Native	Salt Marsh	Producer

Features: Cordgrass is a tall grass that has creeping scaly rhizomes (roots) and numerous spike-like flower clusters. It grows in the mud between low and high tides.

Facts: Cordgrass is a halophyte, which means it is able to grow under saline conditions. It tolerates the salinity by excreting salt through glands on the leaf surfaces. Cordgrass also has hollow tubes in its stems that pass oxygen down the roots from the leaves, even when the plant is submerged for long periods of time. The tops of cordgrass break off in the fall, providing a rich food source for many marine animals. In Upper Newport Bay, elevated nitrogen levels from runoff help the cordgrass to grow taller than in other places, which makes it a superior nesting place for the Light-footed Clapper Rail. Cordgrass—*Spartina foliosa*— is threatened by competition and hybridization with smooth cordgrass—*Spartina alterniflora*—a non-native species.

Common Name:
CORDGRASS

Scientific Name:
Spartina foliosa

Size:
up to 4 feet at maturity

Common Name:
ICE PLANT

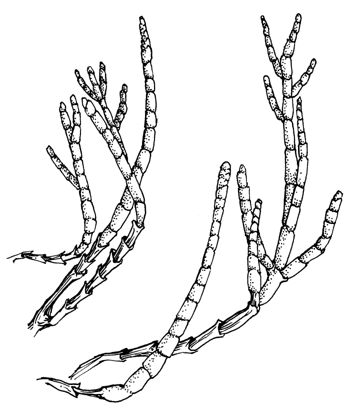
Scientific Name:
Carpobrotus edulis

Size:
Individual clones can grow to at least 165 feet in diameter.

Status:	Habitat:	Trophic Level:
Non-native	Salt Marsh Upland	Producer

Features: Ice plant is a ground-hugging succulent with thick, fleshy leaves. Its yellow, pink, or white flowers are 3 to 4 inches across. This non-native plant spreads quickly by sending out new roots where each leaf meets the stem. One plant can form a dense mat covering a large area.

Facts: Ice plant is native to South Africa and was brought to California in the early 1900s for stabilizing soil along railroad tracks. Since that time, it has been widely planted for soil stabilization and landscaping and has virtually taken over the salt marsh areas in southern California. Ice plant is often stronger than native plants and competes directly with several threatened or endangered plant species for nutrients, water, light, and space. Ice plant also leaches salt into the soil, making it less suitable for native plants. There are several species of ice plant invading the Bay, including hottentot, sea fig, and others. In 2003, volunteers pulled over *17,000 pounds* of ice plant from the Upper Newport Bay area.



Common Name:
PICKLEWEED

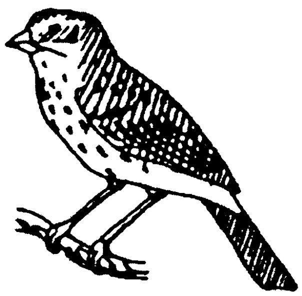
Scientific Name:
Salicornia virginia

Size: 4 ft

Status:	Habitat:	Trophic Level:
Native	Salt Marsh	Producer

Features: Pickleweed is a low-growing succulent with leafless, jointed stems and inconspicuous flowers. The branches are fleshy and segmented. The green stems turn pinkish-red in the fall. Pickleweed grows in extensive colonies in the middle zone of the marsh where the salinity of the soil is high. Dodder *(Cuscuta salina)*—an orange, stringy, parasitic plant—grows on pickleweed.

Facts: Pickleweed is a halophyte, a plant that is able to grow under saline conditions. Pickleweed does not require air passage to its roots, and it tolerates salt by concentrating it in its segmented stems, which turn red and fall off when they become full of salt. Although it does not require a saline environment to survive, it is usually out-competed by other plants in the less saline regions of the marsh. Pickleweed is used by Belding's Savannah Sparrow for nesting, perching, feeding, and shelter. Pickleweed seeds were a favorite Native American food. Today in Great Britain, the plant is used to make pickles.



Common Name:
BELDING'S SAVANNAH SPARROW

Scientific Name:
Passerculus sandwichensis beldingi

Size:
5.5 inches long

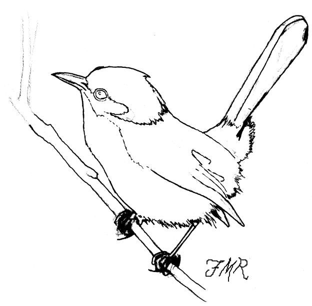
Diet:
carnivorous: insects

Predators:
domestic cats, red foxes

Status:	Habitat:	Trophic Level:
Native Endangered	Salt Marsh	Secondary Consumer

Features: This species of sparrow has dark streaks on its body and a yellow supercillium (eyebrow).

Facts: Belding's Savannah Sparrow nests in the pickleweed at the higher elevations of the Upper Newport Bay salt marsh, above the reach of the highest tide. It is adapted to drinking saltwater. This sparrow is non-migratory, which means it lives in the salt marsh all year. It is endangered by loss of habitat, meaning that it is illegal to impact any area where the species is known to occur. Belding's Savannah Sparrow is one of two wetland-dependent bird species endemic to coastal salt marshes in southern California.



Common Name:
CALIFORNIA GNATCATCHER

Scientific Name: *Polioptila californica californica*

Size: 4 inches long

Diet:
carnivorous: insects

Predators: raccoons, foxes, cats, rodents, crows, scrub-jays, and snakes will eat eggs and young

Status:	Habitat:	Trophic Level:
Native Threatened	Upland	Secondary Consumer

Features: This tiny bird has a black tail with narrow white edges showing from below. Males are slate-blue on back, paler gray underneath, with a black cap in summer. Females are gray-brown. The Gnatcatcher uses its small beak to glean insects out of the air. The bird is easily identified by its song: a kittenlike *meeyew*.

Facts: This nervous little bird is non-migratory, which means that it lives in Upper Newport Bay all year, and it dwells mainly in the coastal sage scrub. The removal of invasive plants improves habitat for this threatened bird. Pairs mate for life and share the tasks of nest building, raising and feeding their young, and driving off predators. A nesting pair can raise two to three broods of young in a season. Their territory is usually a one- to two-acre area that they do not leave during nesting season. Because of loss of habitat, the young may move only one or two miles to find a mate and a new territory.

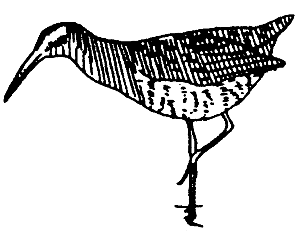
Status: | **Habitat:** | **Trophic Level:**

Status:	Habitat:	Trophic Level:
Native	Mudflat Salt Marsh Riparian	Secondary Consumer

Common Name:
GREAT BLUE HERON
Scientific Name:
Ardea herodias
Size: 4 feet tall;
wingspan to 6 feet;
weighs 5 pounds
Diet: carnivorous:
small fish, frogs, salamanders, lizards, snakes, crawfish, small birds, rodents, insects
Predators: bobcats

Features: The Great Blue Heron is a huge, long-legged, long-necked wader. It has special neck vertebrae that create an "S" shape, which allows the neck to curl up like a spring to attack prey. It also allows the heron to fold its neck while flying. Great Blue Herons are bluish gray in color with a black crown stripe on a whitish head.

Facts: This large heron is usually seen resting in the marsh or fishing in tidal creeks and the shallow waters of the mudflats at high tide. Great Blue Herons are one of the top predators of the Bay food chain. They are commonly seen standing motionless in freshwater or saltwater shallows waiting for small fish, frogs, or invertebrates to pass by. They use their massive bills to spear their prey, toss it into the air, and swallow it whole.

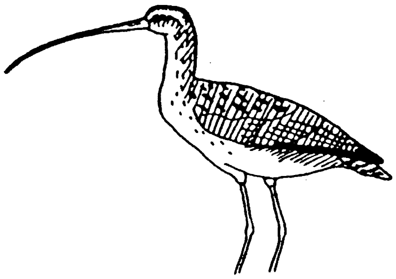


Status:	Habitat:	Trophic Level:
Native Endangered	Salt Marsh	Secondary Consumer

Common Name:
LIGHT-FOOTED CLAPPER RAIL
Scientific Name:
Rallus longisrostris levipes
Size: 14.5 inches long
Diet: carnivorous:
small crabs, clams, mussels, snails, worms, small fish, insects, mice, birds, eggs
Predators: raccoons, red foxes, rats, cats, skunks, hawks, falcons, herons

Features: The Light-footed Clapper Rail is a chicken-sized, brownish wading bird with a cinnamon-colored breast. It has long legs and toes for walking on the salt marsh grasses. It has a long, sturdy, slightly down-curved bill.

Facts: A secretive, elusive bird, the Light-footed Clapper Rail prefers areas with a dense cover of pickleweed and cordgrass. It uses hollow grasses to build a floating nest that it weaves into the surrounding vegetation so that the nest rises with the tide but doesn’t float away. Parents will defend their nest, and you will commonly hear “clapping” calls as the young establish their pecking order. Clapper Rails are good runners, but they don’t fly well. They are year-round residents at Upper Newport Bay. Nearly 70% of the Light-footed Clapper Rails in existence live in Upper Newport Bay.



Common Name:
LONG-BILLED CURLEW

Scientific Name:
Numenius americanus

Size: 19 to 26 inches long

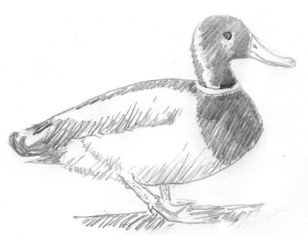
Diet: carnivorous: insects, worms, small crustaceans, mollusks

Predators: coyotes, red foxes, raccoons, snakes

Status:	Habitat:	Trophic Level:
Native	Mudflats	Secondary Consumer

Features: The long-billed curlew is the largest shorebird in North America. It is speckled brown with a small head, large body, and long, decurved bill (downward-curved, versus recurved, which is up-turned). The male and female look alike.

Facts: Curlews use their long bills to probe the mud for invertebrates and are able to reach a food niche that other shorebirds cannot. Curlews are migratory and spend only the winter in the Bay. When a predator threatens, male curlews will work together to defend their nests.

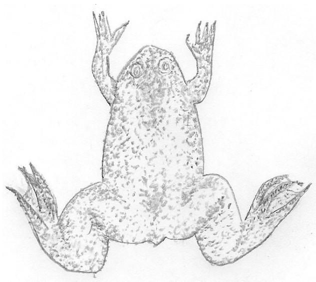


Common Name:
MALLARD DUCK
Scientific Name:
Anas platyrhynchos
Size: male, 20-28 inches long; female smaller
Diet: omnivorous: corn, wheat, barley, bulrushes, wild rice, primrose, willow, seeds of water elm, oak, hackberry and other trees of swamps or river bottoms, mollusks, insects, small fish, tadpoles, freshwater snails, fish eggs, worms
Predators: Foxes, raccoons, cats; large fish will take ducklings

Status:	Habitat:	Trophic Level:
Native	Mudflats	Primary and Secondary Consumer

Features: Male Mallards have an iridescent green head, white neck band, rust-colored breast, very curly tail feathers, and bright orange webbed feet. The females are mottled brown for camouflage during nesting. Both sexes share a blue speculum (a bright blue rectangle of color) and a white bar on each wing. Like most ducks, the Mallard has webbed feet for swimming and a broad beak for scooping up plants and crustaceans and for straining water.

Facts: Mallards are known as “dabbling ducks,” and unlike the “diving ducks,” they just tip their heads under to feed. Mallards are agile fliers who can take off almost vertically, unlike the diving ducks who need a running start. Mallards are migratory and spend their winters in the Bay. The Mallard is the most common duck in North America. Introductions of non-native Mallards to UNB have resulted in a non-native hybridized species which can be seen in Big Canyon. Since signs have been posted to educate the public about the dangers of introducing and feeding ducks, the non-native populations are decreasing.



Common Name: AFRICAN CLAWED FROG

Scientific Name: *Xenopus laevis* (xenopus means "strange foot")

Size: Male, to 3 inches; female, to 6 inches.

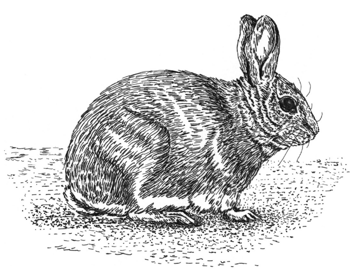
Diet: omnivorous: aquatic insects, small fish, amphibians, tadpoles of its own and other frog species, detritus, anything it can get its claws on!

Predators: possibly great egrets

Status:	Habitat:	Trophic Level:
Non-native	Mudflats	Primary and Secondary Consumer Detritivore

Features: This frog has unusually large, webbed hind feet with five long, webbed toes with dark claws on the three outer toes. It has brown skin with light brown spots, and a flat, wedge-shaped body. It has no eyelids, no visible eardrums, no teeth, no vocal chords or sac, and no tongue. Like a fish, it has a lateral line that detects vibrations in the water.

Facts: The African clawed frog was brought to America in the 1940s to test for pregnancy; when injected with the urine of a pregnant female, the frog produces eggs. Scientists have since found that all frogs have this capability. Crawling from puddle to puddle, clawed frogs invade golf course ponds, streams, ditches, and estuaries like Upper Newport Bay. This frog is salt tolerant and can live without food or water for up to a year by burying itself in mud and lowering its metabolism. It secretes an antibiotic, antifungal, antiparasitic, and antiviral substance that makes life possible in stagnant pools polluted by runoff. This substance is being studied for use as medicine in humans. These introduced frogs voraciously devour anything that crosses their path, including native frogs and fish, resulting in a huge disruption to the food web. Females are reproductively mature at 10 months and may produce up to 120,000 eggs in a lifetime, quickly over-taking native habitats. The importation or possession of clawed frogs is now illegal in many western states, including California.



Common Name: COTTONTAIL RABBIT

Scientific Name: *Sylvilagus audubonii*

Size: 13 to 17 inches long; weighs 2 to 3 pounds; females are larger than males

Diet: herbivorous: 90% grass; also roots, bark, fruits, vegetables

Predators: coyotes, foxes, bobcats, hawks, owls, snakes, cats

Status:	Habitat:	Trophic Level:
Native	Upland	Primary Consumer

Features: A small rabbit that is light tan to gray, with white underneath. The tail is rounded and looks like a cottonball. Cottontails have large hind feet and ears that are relatively short for rabbits.

Facts: Cottontails are active in the early morning, late afternoon, and at night, but may be seen at any time of the day. During the day, they may rest in the shade of large shrubs, in burrows, or within thickets. When startled or frightened, cottontails may freeze, scrunching down to blend into the surroundings, or they may run for cover. They run in a zig-zag pattern, at up to 20 miles per hour. This species has more athletic ability than many other rabbits; cottontails have been seen swimming and climbing trees to escape predators.
Females bear young year round. One cottontail mother may bear twenty to thirty young each year in four to five litters.

Common Name: COYOTE

Scientific Name:
Canis latrans

Size:
40 to 60 inches long;
weighs 15 to 45 pounds

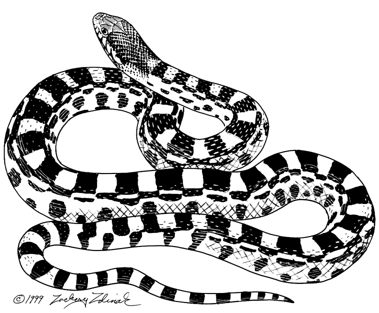
Diet: omnivorous:
small mammals (cats, rabbits, squirrels, mice), fish, reptiles, birds, insects, fruits, vegetables

Predators: humans

Status:	Habitat:	Trophic Level:
Native	Upland	Primary and Secondary Consumer

Features: Coyotes are dog-like animals with brownish-gray fur, triangular ears, a bushy, black-tipped tail, and yellow eyes. Coyotes usually carry their tails straight down and rarely ever walk, preferring an easy lope or trot.

Facts: Coyotes can adapt their diet to whatever is available. Though they are predators that hunt both day and night for small mammals, they will also eat carrion, fruits, grasses, and human garbage. They have good vision and hearing and an acute sense of smell. While hunting, they can run at up to 40 miles per hour. Their adaptability enables them to survive in the suburban areas of large cities. As one of the few top predators that have survived urban encroachment, their ability to control small mammal populations makes them a very important link in the food web.



Common Name:
GOPHER SNAKE

Scientific Name:
Pituophis melanoleucus

Size: 5 to 6 feet long

Diet: carnivorous:
rodents, gophers, rabbits, birds, eggs, lizards

Predators: hawks, foxes, coyotes

Status:	Habitat:	Trophic Level:
Native	Upland	Secondary Consumer

Features: A large, heavy snake with a yellow or cream background color and black, brown, or reddish-brown blotches on its back and sides. A dark stripe runs across its small head.

Facts: Gopher snakes usually hunt during the day by moving slowly through burrows and nests, using their keen sense of smell to find rodents, rabbits, or baby birds and eggs. They kill their prey by constriction and swallow it whole. If the weather is very hot, they will rest during the day and hunt at night.
When a gopher snake is threatened, it hisses loudly and sometimes flattens its head and vibrates its tail, although it has no rattle. This behavior, along with the similarity in color and pattern, often causes them to be mistaken for rattlesnakes.

Common Name:
HUMAN BEING

Scientific Name:
Homo sapiens

Size: varies greatly; average 5 to 6-1/2 feet tall, 100 to 250 pounds

Diet: omnivorous: cows, pigs, chickens, fish, shellfish, fruits, seeds, vegetables

Predators: none

Status:	Habitat:	Trophic Level:
Native	Upland	Primary and Secondary Consumer

Features: Humans are bipedal (two-legged) primate mammals with a highly developed brain, a capacity for articulate speech and abstract reasoning, and the ability to create and use complex tools.

Facts: Humans inhabited Upper Newport Bay over 9,000 years ago. Native Americans known as the Tongva (or Gabrielinos) were here 2,000 years ago, subsiding on fish and plants in the Bay. Humans are able to live in any climate or zone. They are at the top of the food chain. Their activities often cause changes in the environment. In Orange County, where Upper Newport Bay is located, the human population has exploded over the past 50 years, from 216,224 in 1950 to 2,978,800 in 2003—almost 14 times as many people—making it the fifth most populated county in the nation.

Common Name:
RACCOON

Scientific Name:
Procyon lotor

Size: 26 to 40 inches long; weighs 10 to 30 pounds

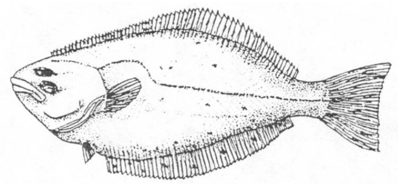
Diet: omnivorous: fish, shellfish, frogs, salamanders, insects, birds, eggs, mice, carrion, fruit, nuts, vegetation, corn, cat food, human garbage

Predators: bobcats, coyotes, foxes, owls, dogs, humans

Status:	Habitat:	Trophic Level:
Native	Upland Riparian Coastal	Primary and Secondary Consumer

Features: Raccoons are easily recognized by the black "mask" across their eyes and bushy, ringed tail. Their long, coarse hair is grayish with black tips, and they have a broad head with a pointed snout. Their finger-like toes are long, thin, and flexible, making them able to handle objects very much like humans.

Facts: Raccoons are highly opportunistic and will eat just about anything they can get, which enables them to thrive in many cities as well as wilderness areas. Raccoons are typically active at night, looking for food and often "washing" or dipping their food in water. In some areas, raccoons have become pests, able to open doors and trash cans in their hunt for food.



Common Name:
CALIFORNIA HALIBUT

Scientific Name:
Paralichthys californicus

Size: up to 5 feet long; weighs up to 72 pounds

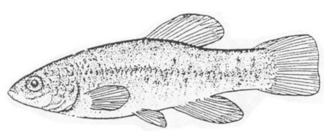
Diet: carnivorous: small fish, squid

Predators: sharks, sea lions, humans

Status:	Habitat:	Trophic Level:
Native	Open Water	Secondary Consumer

Features: The California halibut is a flatfish, distinguished by its large mouth with sharp teeth and a line running along its side that arches up and over its fin. The upper side, where the eyes are, is brown to gray-green with splotches, and the underside is white. Like most flatfish, a halibut's eyes migrate from an initial left-right symmetric position to one side of the body. Whereas most flatfish are either right-eyed or left-eyed, California halibut can be both. In UNB, 68 percent of this species have their eyes located on the left side. If the eye does not migrate properly, the fish's brain doesn't turn off pigment production on the bottom side and both sides remain colored.

Facts: A California halibut can match its skin coloration to whatever bottom it lies on, and it can bury itself up to its eyes in the sand. Halibut feed by swimming in anchovy schools and even leap out of the water in pursuit of an anchovy. During spawning season, halibut migrate to shallower water to lay their eggs. When hatched, many halibut make their way to UNB and other wetland waters, where they spend their juvenile lives enjoying protection from open ocean predators. The largest halibut caught in the Bay weighed over 50 pounds! Halibut in Newport Bay have shown potentially dangerous levels of PCBs and DDT and may pose a health hazard if eaten, according to Orange County health officials.



Common Name:
CALIFORNIA KILLIFISH

Scientific Name:
Fundulus parvipinnis

Size: 2 to 4 inches long

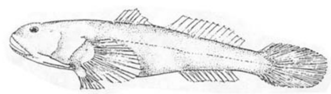
Diet: omnivorous: insects, amphipods, copepods, algae, worms, fish eggs, snails

Predators: herons, egrets, ducks, larger fish, humans (sportfishers use killifish as bait)

Status:	Habitat:	Trophic Level:
Native	Brackish Water	Primary and Secondary Consumer

Features: The killifish is pale olive green with splotches on the upper surface. The fins are transparent, becoming bright yellow in the breeding season. The male has about 20 crossbars; the female has seven to eight. The killifish has a protruding lower jaw and a tilted mouth for surface feeding.

Facts: These small fish are commonly found in salt marshes. They tolerate a wide range of temperatures and salinities, from fresh to seawater, making them good bait fish. When disturbed, they often bury themselves head-first in the mud. While most fish have external fertilization, killifish have internal fertilization and give birth to live young. Killifish host the adult stage of a parasite that depends on the fish being eaten by a bird to complete its life cycle. To increase the chance that the killifish is eaten by a bird, the parasite infects the fish's brain, causing it to swim erratically at the surface to attract a bird's attention.



Common Name:
LONGJAW MUDSUCKER

Scientific Name:
Gillichthys mirabilis

Size: up to 4 inches long

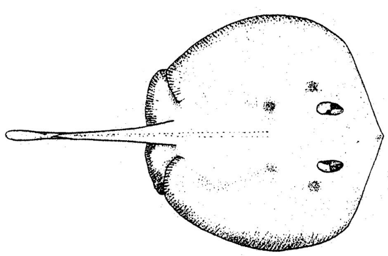
Diet: carnivorous: ghost shrimp, crabs

Predators: larger fish, egrets, herons, humans (sportfishers use the mudsucker as bait)

Status:	Habitat:	Trophic Level:
Native	Mudflats	Secondary Consumer

Features: This fish is brownish to olive in color with dark spots. It has a large mouth with the upper jaw reaching as far back as the pectoral fin. The face is bluntly rounded. The pelvic fins unite to form a deep, pocketed cup which allows the fish to attach to the substrate.

Facts: Mudsuckers are adapted specifically for life on the mudflats. They are able to burrow into the mud and survive under extreme conditions of reduced oxygen and elevated temperature. Instead of breathing with gills like most fish, longjaw mudsuckers absorb oxygen from the air through veins in their mouths. Because of their ability to live many minutes or even hours without breathing, mudsuckers are being studied for a cure for sleep apnea, a disorder in which people stop breathing periodically during their sleep. Male mudsuckers build nests in mud banks and defend their territories by raising their fins, which turn black, opening their jaws wide, and pushing intruders with their mouths.



Common Name:
ROUND STINGRAY

Scientific Name:
Urolophus halleri

Size: up to 22 inches long

Diet: carnivorous: worms, crabs, clams

Predators: northern elephant seal, sharks

Status:	Habitat:	Trophic Level:
Native	Sandy Bay Bottom	Secondary Consumer

Features: The round stingray gets its name from its flat, nearly circular body. The tail is longer than the body and contains a poisonous barb about halfway down its length. This ray is grayish brown on top, sometimes with white spots, and yellowish below.

Facts: Round stingrays lay motionless during the day and dig for worms and crustaceans at night. When the rays rest on the bottom they use their spiracles—"holes" on the top of their bodies—to breathe instead of their gills, which are located on the underside of their bodies. If stepped on, the stingray arches its tail and jabs the spine into the swimmer's foot or leg. The painful wound may be treated with hot water, which breaks down the neurotoxin released from the barb. The females are ovoviparous, which means eggs hatch inside the mother's body and she gives birth to live young. When the babies are born, they are rolled up in a cigar shape so that the mother is not harmed by the barb when she gives birth. Stingrays are born in shallow waters, where they stay until they are large enough—and brave enough—to venture into deeper seas.

Common Name: GRAY SMOOTHHOUND SHARK

Scientific Name: *Mustelus californicus*

Size: 2 to 4 feet long; females are larger than males

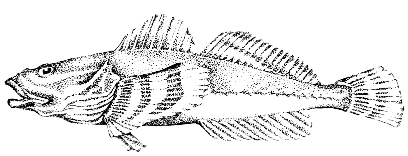
Diet: carnivorous: worms, clams, crabs, shrimp, octopuses, small fish

Predators: humans

Status:	Habitat:	Trophic Level:
Native	Open Water	Secondary Consumer

Features: This shark's body is long and slender, and its head has a long, flattened snout. Coloration is brown to dark gray above and whitish below. This counter-shading is an adaptation that helps camouflage; seen from below a white belly will blend with surface light, from above the dark body disappears into the background. The gray smoothhound shark has short, blunt teeth and small grinding plates that are well adapted to feeding on shellfish.

Facts: These sharks often form loose schools with leopard sharks. Sometimes called sand sharks, mud sharks, palomas, or dogfish, smoothhound sharks are found frequently in the Upper Newport Bay, usually near Newport Dunes or Big Canyon. They spend most of their lives in the protected waters of bays or estuaries, and are rarely found outside of this type of protected water. Females give birth to living young (viviparity) as opposed to laying eggs (oviparity).



Common Name: STAGHORN SCULPIN

Scientific Name: *Leptocottus armatus*

Size: up to 1 foot long

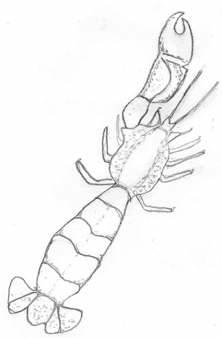
Diet: omnivorous: crustaceans, shrimp, mollusks, worms, small fish, plant material

Predators: egrets, herons, humans

Status:	Habitat:	Trophic Level:
Native	Open Water Mudflats	Primary and Secondary Consumer

Features: Sculpins have large depressed heads with large mouths. Their eyes are located high on the head. Their tapering bodies are elongated, scaleless, and slimy. The pectoral fins are yellow with dark crossbars, and the spiny dorsal fin has a large dark spot. The most striking characteristic of this species is an antler-like spine located just forward of the gill cover.

Facts: The Pacific staghorn sculpin can actually walk on its pectoral fins. To protect itself from predators, its body color blends with the environment, a defense mechanism known as crypsis. Other defense mechanisms include burying itself in the sand to hide or erecting its spines to warn-off predators.



Common Name:
BAY GHOST SHRIMP

Scientific Name:
Callianassa californiensis

Size: 4 to 5 inches long

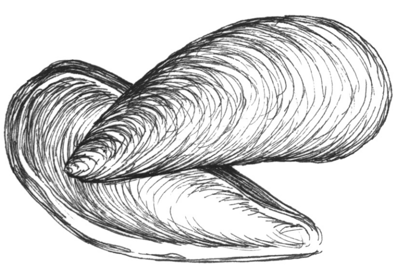
Diet: omnivorous: plankton, detritus

Predators: fish, sharks, shorebirds, humans (sport-fishers use a device called a slurp gun to suck the shrimp out of their burrows to use as bait)

Status:	Habitat:	Trophic Level:
Native	Mudflats	Primary and Secondary Consumer Detritivore

Features: The soft shell of this shrimp is pale pink and orange. The adult males have one pincer that is much larger than the other. The ghost shrimp has four pairs of legs and a large fan-shaped tail.

Facts: This shrimp burrows constantly, forming ever-changing tunnels as deep as 30 inches with many branches. It extends its fourth pair of legs against the walls of its burrow for support while digging with the second and third pairs. Its tail is used to block burrow entrances for protection. It filters and ingests detritus and plankton from the continuous stream of mud that circulates through its burrow as it digs. Other invertebrates, such as pea crabs and scale worms, live commensally in the bay ghost shrimp's burrows, finding leftover food and protection from predators. The bay ghost shrimp can tolerate large changes in salinity and live without oxygen for more than five days by lowering its heart rate and respiration. Due to their burrowing activity, ghost shrimp play an important role in turning over and aerating the bottom sediments of Upper Newport Bay, similar to the earthworm's function on land.



Common Name:
BAY MUSSEL

Scientific Name:
Mytilus edulis

Size: 4 to 5 inches long, 2 to 3 inches wide

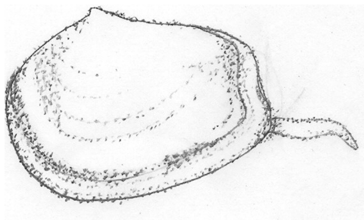
Diet: omnivorous: detritus, plankton

Predators: seastars, snails, crabs, ducks, sea birds, humans

Status:	Habitat:	Trophic Level:
Native	Mudflats	Primary Consumer Detritivore

Features: The bay mussel is a bivalve (two-shelled) mollusk with a dark, blue-black shell. Mussels grow in large clumps on rocks and man-made structures such as piers and docks.

Facts: Mussels attach themselves to rocks and to each other by secreting a thick liquid that in saltwater forms thread-like fibers called "byssal threads." Byssal threads are an area of interest to scientists because they have a tensile strength similar to steel! The tangled mass of mussels and byssal threads forms homes for numerous small creatures.
As the bay mussel feeds, its shell opens slightly and tiny hairs, or cilia, beat rhythmically to draw in water carrying tiny particles of food. To collect enough food to survive, a mussel filters two to three quarts of water an hour, helping to clean the Bay of excess nutrients from run-off. Mussels will reproduce unchecked if their predators are removed. Mussels are cultivated extensively for food in Europe, but this delicacy is generally overlooked in California.



Common Name:
BENTNOSE CLAM

Scientific Name:
Macoma nasuta

Size: up to 2 inches long

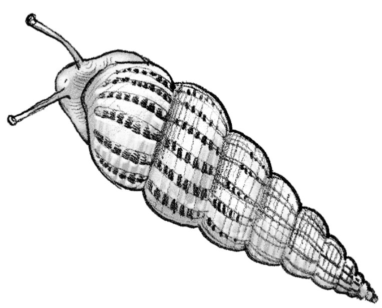
Diet: filter feeder: detritus, bacteria, plankton

Predators:
shorebirds, moon snail

Status:	Habitat:	Trophic Level:
Native	Mudflats	Primary Consumer Detritivore

Features: The bentnose clam is a bivalve (two-shelled) mollusk with a whitish shell. It has two white, very long siphons that become orange when contracted. This clam always lies on its left side with the bend in its shell turned upwards, following the curve of the siphons. When viewed edge-on, its shells are bent to the right side, giving it the name "bentnose clam."

Facts: This clam is commonly found buried four to six inches deep in Upper Newport Bay. It buries itself in the mud and sand with its muscular foot. When burrowing, it goes in at an angle, sawing back and forth like a coin sinking in water. It uses its siphons to sweep the bay floor like a vacuum, bringing seawater into its body and filtering out detritus and plankton for food. Native Californians made extensive use of the bentnose clam for food; many of their refuse piles of shells—called middens—contain more shells of this species than any other.



Common Name:
CALIFORNIA HORN SNAIL

Scientific Name:
Cerithidea californica
(cerith is Greek for 'horn')

Size: 1-3/4 inches long

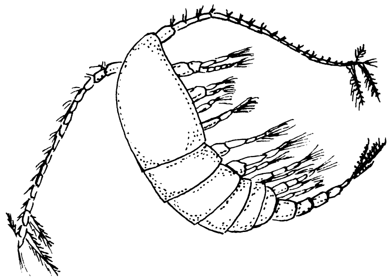
Diet: herbivorous: detritus and benthic diatoms (which form a dense mucus mat on the surface of the mud)

Predators:
killifish, shorebirds

Status:	Habitat:	Trophic Level:
Native	Mudflats	Primary Consumer

Features: This snail is slender, from one to one and three-quarter inches long with a brown, spiral shell.

Facts: The California horn snail is the most common snail on the mudflats of UNB, often forming dense clusters exposed at low tide, as if someone spilled a package of chocolate chips on the mudflat. This snail has the important role of cleaning decaying plants and algae from the mudflats, upholding wetlands' reputation for high productivity. It is extremely tolerant of estuarine conditions, being able to survive for many days in fresh water. Studies have found the local population to be infected with numerous parasites that are transferred to the birds and fish feeding on the horn snails.

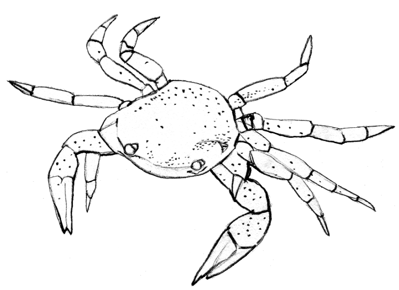


Common Name: COPEPOD
(means "oar feet")
Scientific Name: There are 10 orders and 4,500 species, example: *Calanus finmarchicus*
Size: microscopic to 1/4 inch long
Diet: plankton
Predators: mussels, fish and fish larvae, squid, sea birds, baleen whales, some seals

Status:	Habitat:	Trophic Level:
Native	Water in all zones	Primary Consumer

Features: Copepods are tiny, shrimp-like crustaceans with a hard exoskeleton, ten jointed legs, and a segmented body. The legs are used for swimming and the abdomen functions like a rudder, to help copepods steer. Copepods have a single simple eye in the middle of the head (sometimes it is present only in the larval stage), which can differentiate between light and dark. They have two pairs of antennae; one pair is long and one pair is short.

Facts: Copepods comprise the largest group of zooplankton. Found almost everywhere there is water, copepods constitute the biggest source of protein in the oceans. Scientists have found up to 1,000 copepods in one liter of water when abundance peaks in September. Small fish feed on copepods and are in turn eaten by bigger fish, sea birds, and seals. Thus, copepods are the foundation for many aquatic food webs.



Common Name: LINED OR STRIPED SHORE CRAB
Scientific Name: *Pachygrapsus crassipes*
Size: carapace up to 2 inches wide
Diet: omnivorous: algae and diatoms, dead animal matter, small live prey (limpets, snails, hermit crabs)
Predators: birds, rats, raccoons, humans

Status:	Habitat:	Trophic Level:
Native	Salt Marsh Mudflats	Primary and Secondary Consumer Detritivore

Features: This small crab has two claws tipped with small spoon-shaped cups to scrape algae off rocks. It has a hard shell that is green, black, or purple with horizontal stripes in green or white.

Facts: Abundant in crevices, mussel beds, and hard muddy shores, this crab has adapted to spending at least half its time on land by retaining water in its gill chamber. It submerges now and then to wet its gills and feed. To grow, crabs must periodically shed their shells (molt). To escape enemies, crabs can shed their legs or claws, which regenerate after a few molts. To defend itself, this crab runs quickly—sideways or backwards—or fights with its pincers. Combined with tidal action, the burrows dug by shore crabs will undercut the pickleweed on the banks and cause whole sections of salt marsh to collapse into the bay, expanding the mud flat habitat.

APPENDIX B
Species Common to Upper Newport Bay

Plants

arroyo willow
black mustard
broadleaf cattail
bush sunflower
California sagebrush
California buckwheat
cordgrass
cottonwood
eel grass
elderberry
giant reed
ice plant
Laguna live-forever
mulefat
Myoporum tree
pampas grass
pepper tree
phytoplankton
pickleweed
prickly pear cactus
saltbush
salt grass
salt marsh bird's beak
sea lavendar
sweet fennel
toyon
yellow star thistle

Birds

American Avocet
American Coot
Anna's Hummingbird
Belding's Savannah Sparrow
Black-necked Stilt
Black Skimmer
Brown Pelican
California Gnatcatcher
Common Yellowthroat
Cormorant
Eared grebe
Forster's Tern
Great Blue Heron
Great Egret
Light-footed Clapper Rail
Long-billed Curlew
Mallard Duck
Marbled Godwit
Marsh Wren
Northern Harrier
Osprey
Pintail Duck
Red-tailed Hawk
Red-winged Blackbird
Ring-billed Gull
Ruddy Duck
Snowy Egret
Turkey Vulture
Western Sandpiper
Willet

Land Animals

African clawed frog
California ground squirrel
common king snake
cottontail rabbit
coyote
deer mouse
gopher snake
human
Pacific chorus frog
raccoon
red fox
southern alligator lizard
striped skunk
western fence lizard
western pond turtle
western rattlesnake

Fish

barred sand bass
bat ray
bluegill
California killifish
California halibut
croaker
C-O turbot
deepbody anchovy
diamond turbot
smoothhound shark
leopard shark
longjaw mudsucker
mosquitofish
opal eye
round stingray
spotted bay bass
shiner surfperch
shovelnose guitarfish
staghorn sculpin
topsmelt

Other Marine Animals

annelid worms
bay ghost shrimp
bay mussels
bentnose clam
California horn snail
scallops
striped shore crab
zooplankton

APPENDIX C

Environmental Organizations

The following is a brief list of organizations and agencies that offer programs related to wetlands, the coast, and/or the ocean. They may provide field trips, informational material, expert advice, or other resources. Contact the organizations directly for details. For an up-to-date, more extensive list of organizations, along with information about their programs, visit the California Coastal Commission's "Marine, Coastal & Watershed Resource Directory" at www.coastforyou.org.

Southern California Focus

Acorn Naturalists
155 El Camino Real
Tustin, CA 92780
(800) 422-8886
www.acornnaturalists.com

Amigos de Bolsa Chica
16531 Bolsa Chica Street Suite 312
Huntington Beach, CA 92649
(714) 840-1575
www.amigosdebolsachica.org

Aquarium of the Pacific
100 Aquarium Way
Long Beach, CA 90802
(562) 590-3100
www.aquariumofpacific.org

Aquatic Adventures Science Education Foundation
1010 Santa Clara
San Diego, CA 92109
(858) 488-3849
www.aquaticadventures.org

Back Bay Science Center
600 Shellmaker Road
Newport Beach, CA 92660
(949) 640-9956
www.backbaysciencecenter.org

The Birch Aquarium at Scripps
9500 Gilman Drive, Dept. 0207
La Jolla, CA 92093
(858) 534-FISH
www.aquarium.ucsd.edu

Bolsa Chica Conservancy
3842 Warner Avenue
Huntington Beach, CA 92469
(714) 846-1114
www.bolsachica.org

Bolsa Chica Land Trust
5200 Warner Avenue #108
Huntington Beach, California 92649
(714) 846-1001
www.bolsachicalandtrust.org

Cabrillo Marine Aquarium
3720 Stephen White Drive
San Pedro, CA 90731
(310) 548-7562
www.cabrilloaq.org

The Catalina Island Marine Institute
P.O. Box 1360
Claremont, CA 91711
909-625-6194
www.guideddiscoveries.org/cimisite/school.htm

Catalina Environmental Leadership Program
P.O. Box 5083
Avalon, CA 90704
(800) 696-2267
www.celp.net

Chula Vista Nature Center
1000 Gunpowder Point Drive
Chula Vista, CA 91910
(619) 409-5900
www.chulavistanaturecenter.org

City of Newport Beach
Tide Pool Preservation Project
829 Harbor Island Drive
Newport Beach, CA 92660
(949) 644-3038
www.city.newport-beach.ca.us/hbr

Community Environmental Council
Watershed Resource Center
2981 Cliff Drive
Santa Barbara, 93109
(805) 682-6113
www.communityenvironmentalcouncil.org

Crystal Cove Interpretive Association
8471 Pacific Coast Highway
Laguna Beach CA 92651
(949) 494-3539
www.crystalcovestatepark.com

Defend the Bay
471 Old Newport Boulevard, Suite 200
Newport Beach, CA 92663
(949) 722-7822
www.defendthebay.org

Earth Resource Foundation
230 E. 17th Street, Suite 208
Costa Mesa, CA 92627
(949) 645-5163
www.earthresource.org

El Dorado Nature Center
7550 East Spring Street
Long Beach, CA 90815
(562) 570-1745
www.ci.long-beach.ca.us/park

Environmental Nature Center
1601 Sixteenth Street
Newport Beach, CA 92663
(949) 645-8489
www.ENCenter.org

Inside the Outdoors
Orange County Department of Education
200 Kalmus Drive
Costa Mesa, CA 92628
(714) 708-3885
www.insidetheoutdoors.org

Heal the Bay
3220 Nebraska Avenue
Santa Monica, CA 90404
(800) HEAL-BAY
www.healthebay.org

Heal the Ocean
P.O. Box 90106
Santa Barbara, CA 93190
(805) 965-7570
www.healtheocean.org

Long Beach Marine Institute
Box 281
6475 E. Pacific Coast Highway
Long Beach, CA 90803
(562) 431-7156
www.longbeachmarineinst.com

I Love A Clean San Diego
4891 Pacific Highway, Suite 115
San Diego, CA 92110
(619) 291-0103
www.ilacsd.org

Malibu Foundation
for Environmental Education
1471 S. Bedford Street #3
Los Angeles, CA 90035
(310) 652-4324
www.malibufoundation.org

Mountain and Sea Adventures
P.O. Box 5084
Avalon, CA 90704
(310) 510-2695
www.mountainandsea.org

Natural History Museum
of Los Angeles County
900 Exposition Boulevard
Los Angeles, CA 90007
(213) 763-DINO
www.nhm.org

Santa Barbara Museum of Natural History, Ty Warner Sea Center
211 Stearns Wharf
Santa Barbara, CA 93101
(805) 962-2526
www.sbnature.org/seacenter

Newport Bay Naturalists and Friends
600 Shellmaker Road
Newport Beach, CA 92660
(949) 640-6746
www.newportbay.org

Ocean Institute
24200 Dana Point Harbor Drive
Dana Point, CA 92629
(949) 496-2274
www.ocean-institute.org

Orange County Coastkeeper
441 Old Newport Boulevard,
Suite 103
Newport Beach, CA 92663
(949) 723-5424
www.coastkeeper.org

Peter & Mary Muth
Interpretive Center
2301 University Drive
Newport Beach, CA 92660
(949)923-2290
www.ocparks.com/unbic

Roundhouse Marine Studies Lab
& Aquarium
End of the Manhattan Beach Pier
Manhattan Beach, CA 90266
310-379-8117
www.roundhousemb.com

San Diego Baykeeper
2924 Emerson Street, Suite 220
San Diego, CA 92106
(619) 758-7743
www.sdbaykeeper.org

San Dieguito River Park
18372 Sycamore Creek Road
Escondido, CA 92025
(858) 674-2270
www.sdrp.org

Santa Monica BayKeeper
P.O. Box 10096
Marina del Rey, CA 90295
(310) 305-9645
www.smbaykeeper.org

Santa Monica Bay
Restoration Commission
320 West 4th Street,
Suite 200
Los Angeles, CA 90013
(213) 576-6615
www.santamonicabay.org

Sea and Sage Audubon Society
P.O. Box 5447
Irvine, CA 92616
(949) 261-7963
www.seaandsageaudubon.org

Sea Camp San Diego
1380 Garnet Avenue
PMB E6
San Diego, CA 92109
(858) 268-0919
www.seacamp.com

SeaLab in Redondo Beach
1021 North Harbor Drive
Redondo Beach, CA 90277
(310) 318-7438
www.lacorps.org

Southern California Coastal Water
Research Project Authority
7171 Fenwick Lane
Westminster, CA 92683
(714) 894-2222
www.sccwrp.org

Southern California Marine Institute
820 South Seaside Avenue
Terminal Island, CA 90731
(310) 519-3172
www.scmi.us

Southern California Wetlands
Recovery Project
P.O. Box 22405
Santa Barbara, CA 93121
(805) 892-4858
www.scwrp.org

University of Southern California
Sea Grant Program
University Park, AMF 209
Los Angeles, CA 90089-0373
(213) 740-1961
www.usc.edu/org/seagrant

Statewide Focus

Adopt-A-Watershed
P.O. Box 1850
Hayfork, CA 96041
(530) 628-5334
www.adopt-a-watershed.org

Algalita Marine Research Foundation
148 Marina Drive
Long Beach, CA 90803
(562) 598-4889
www.algalita.org

California Aquatic Science Education Consortium (CASEC)
www.rain.org/casec

California Center for Ocean Sciences Education Excellence (COSEE)
www.cacosee.net

California Coastal Commission
45 Fremont Street, Suite 2000
San Francisco, CA 94105
(800) Coast-4U
www.coastforyou.org

California Coastal Conservancy
1330 Broadway, 11th Floor
Oakland, CA 94612
(510) 286-1015
www.coastalconservancy.ca.gov

California Department
of Conservation
California Geological Survey
801 K Street, MS 12-30
Sacramento, CA 95814
(916) 445-1825
www.consrv.ca.gov/cgs

California Department
of Fish and Game
1416 Ninth Street
Sacramento, CA 95814
(916) 445-0411
www.dfg.ca.gov

California Department
of Water Resources
1416 Ninth Street
Sacramento, CA 95814
(916) 653-5791
www.dwr.water.ca.gov

California Native Plant Society
2707 K Street, Suite 1
Sacramento, CA 95816
(916) 447-2677
www.cnps.org

California State Parks
1416 Ninth Street
Sacramento, CA 95814
(800) 777-0369
www.parks.ca.gov

California Regional Environmental Education Community (CREEC) Network
www.creec.org

Keep California Beautiful
3914 Murphy Canyon Road,
Suite A-218
San Diego, CA 92123
(858) 505-9936
(800) CLEAN-CA
www.keepcaliforniabeautiful.com

State Water Resources Control Board
1001 I Street
Sacramento, CA 95814
(916) 341-5250
www.waterboards.ca.gov

Surfrider Foundation
P.O. Box 6010
San Clemente, CA 92674-6010
(949) 492-8170
www.surfrider.org

The Ocean Conservancy
2029 K Street
Washington, DC 20006
(202) 429-5609
www.oceanconservancy.org

U.S. Geological Survey
Marine and Coastal Issues
345 Middlefield Road, MS 999
Menlo Park, CA 94025
(650) 329-5042
walrus.wr.usgs.gov

Water Education Foundation
717 K Street, Suite 317
Sacramento, CA 95814
(916) 444-6240
www.watereducation.org

Wyland Foundation
www.wylandfoundation.org

APPENDIX D

Southern California Wetlands
5437.55 Total Salt Marsh Acres

San Diego County – 1908 acres

Tijuana Estuary – 615 acres
Tijuana Estuary Visitor Center (619) 575-3613 or (619) 575-2704
Tijuana River National Estuary Research Reserve, *www.nerrs.noaa.gov/TijuanaRiver*

San Diego Bay – 300 acres
Chula Vista Nature Center (619) 409-5900
U.S. Fish and Wildlife Service,
Carlsbad Field Office (760) 431-9440

Famosa Slough – 6 acres
City of San Diego Department of
Parks and Recreation,
Open Space Management Division
(619) 533-6713
Friends of Famosa Slough (619) 224-4591

Mission Bay – 231 acres
City of San Diego Department of
Parks and Recreation (619) 525-8219
UC Natural Reserve System,
Kendall-Frost Reserve (858) 534-2077

Los Penasquitos Lagoon – 350 acres
Torrey Pines State Park (858) 755-2063

San Dieguito Lagoon – 118 acres
San Dieguito River Park (858) 674-2270

San Elijo Lagoon – 78 acres
San Diego County Parks and Recreation
(858) 694-3049
San Elijo Lagoon Conservancy
(760) 436-3944
California Department of Fish and Game,
San Diego Field Office
(858) 467-4202

Batiquitos Lagoon – 100 acres
Batiquitos Lagoon Foundation
(760) 931-0800
California Department of Fish and Game,
San Diego Field Office
(858) 467-4202
U.S. Fish and Wildlife Service,
Carlsbad Field Office (760) 431-9440

Agua Hedionda Lagoon – 14 acres
Agua Hedionda Lagoon Foundation
(760) 804-1969

Buena Vista Lagoon – 14 acres
California Department of Fish and Game
(858) 467-4201
Buena Vista Lagoon Foundation
(760) 727-3866
Buena Vista Lagoon Visitor's Center
(760) 439-BIRD

San Luis Rey River Estuary
Riparian and mud flats
San Diego County Department of
Parks and Recreation (858) 694-3024
San Diego Association of Governments
(619) 699-1900

Santa Margarita River Estuary – 81 acres
U.S. Environmental Protection Agency
(415) 947-8000
U.S. Fish and Wildlife Service,
Carlsbad Field Office (760) 431-9440
U.S. Marine Corps Base Camp Pendleton, Land
Management Branch (760) 725-9728

Las Flores Lagoon – 1 acre
U.S. Fish and Wildlife Service,
Carlsbad Field Office (760) 431-9440
U.S. Marine Corps Base Camp Pendleton, Land
Management Branch (760) 725-9728

San Mateo Lagoon – mostly riparian
U.S. Marine Corps Base Camp Pendleton, Land
Management Branch (760) 725-9728
California Department of Parks and Recreation,
Orange County District (949) 492-0802

Orange County – 1514.9 acres

Santa Ana River Mouth Estuary – 59 acres
U.S. Army Corps of Engineers,
Los Angeles District (213) 452-3908/3333
Orange County Resources and Development
Management Department (714) 834-4643

Upper Newport Bay – 382 acres
Newport Bay Naturalists and Friends
(949) 640-6746
Orange County Harbors, Beaches and Parks
(949) 923-2290
California Department of Fish and Game
Regional Headquarters (858) 467-4201
California Department of Fish and Game,
Upper Newport Bay Ecological Reserve
(949) 640-9958
Orange County Resources and Development
Management Department (714) 834-4643

Huntington Beach Wetlands
125 acres: 11 restored/ 114 degraded
City of Huntington Beach Community Services
(714) 536-5486
Orange County Resources and Development
Management Department (714) 834-6192

Bolsa Chica Wetlands – 368 acres
City of Huntington Beach Community Services
(714) 536-5486
California Department of Fish and Game
(949) 640-9958
Amigos de Bolsa Chica (714) 840-1575
Bolsa Chica Conservancy (714) 846-1114
Bolsa Chica Land Trust (714) 846-1001

Anaheim Bay – 566 acres
City of Huntington Beach Community Services
(714) 536-5486
Seal Beach National Wildlife Refuge Visitor
Center (562) 598-1024
Seal Beach Naval Weapons Station
(562) 626-7215
City of Seal Beach (562) 431-2527

Hellman Ranch – 14.9 acres
Dave Bartlett, consultant to the major landowner
(714) 898-0600
California Coastal Commission,
Southern Coast Area Office
(562) 590-5071

Los Angeles County – 698.7 acres

Los Cerritos Wetlands – 19.2 acres

Jack Dunster Marine Reserve – 1.4 acres
Golden Shores Marine Reserve – 6.4 acres
City of Long Beach
www.longbeach.gov/park/facilities/parks

Ballona Wetlands – 39 acres
Friends of Ballona Wetlands Education/Ecology Center (310) 306-5995

Del Rey Lagoon
Malibu Lagoon – 17.7 acres
Santa Monica Mountains
Resource Conservation District
(310) 455-1030
California Department of Parks and Recreation, Los Angeles County District (818) 880-0350
City of Malibu (310) 456-2489

Ventura County – 1061.9 acres

Mugu Lagoon – 943.5 acres
Naval Base Ventura County Public Affairs Office
(805) 989-8094

Ormond Beach Wetlands – 100 acres
City of Oxnard –
Department of Community Development
(805) 385-7407

Santa Clara River Estuary – 5.2 acres
Ventura County Watershed Protection
(805) 654-2001

Ventura River Estuary – 13.2 acres
City of San Buenaventura (805) 654-7800
Ojai Valley Land Consevancy (805) 646-7930

Santa Barbara County – 254.05 acres

Carpinteria Salt Marsh – 133 acres
City of Carpinteria (805) 684-5405
Land Trust for Santa Barbara County
(805) 966-4520
UCSB Natural Reserve System (805) 893-2401

UCSB Campus Lagoon – 1.75 acres
Cheadle Center for Biodiversity and Ecological Restoration (805) 893-2506
UCSB Office of Campus Planning and Design
(805) 893-8430

Goleta Slough – 101 acres
Cheadle Center for Biodiversity and Ecological Restoration (805) 893-2506
City of Santa Barbara - Planning Division
(805) 564-5470
Santa Barbara Municipal Airport
(805) 967-7111

Devereux Slough – 18.3 acres
Coal Oil Point Reserve - UCSB Natural Reserve System (805) 893-5092
Devereux School - Santa Barbara
(805) 968-2525

APPENDIX E

Correlations to California State Standards for Grade 9-12

Activity	Science	English-Language Arts	History/Social Science	Mathematics
Mapping Your Watershed	B 6b E 9a,c I 1h			
Wetland Habitats	B 6e I 1g			
Explore a Wetland	B 6a,b,e I 1c,j,k			
Wetland Webs	B 6e,f	9-10 R 2.3, 2.5 9-10 LS 2.2b,e; 2.3a,b,d,e,f; 2.6a,b,c 11-12 LS 1.8		
Wetland Soil	B 6d I 1c,g,i,j,k	9-10 R 2.3		
Measuring Decomposition	C 3a,e; 5a,d; 6d; 8a,b,c B 6d,e I 1a,c,g,j			AI 3.0, 15.0
Changes Over Time	B 6b E 9a,c I 1d,i			
Nonpoint Source Pollution	B 6b I 1a	9-10 W 2.3a,b,c 11-12 W 2.3a,b,c		
Water Quality	C 5a,d B 6b I 1a,b,c	9-10 R 2.6		
Pollution Observation	C 5a B 6b,d E 7a I 1c,d,g,j			

Activity	Science	English-Language Arts	History/Social Science	Mathematics
Space for Species	B 6a,b; 8b I 1a,c,d,g,k			PS 8.0
Species in Peril	B 6a,b,c; 8b	9-10 R 2.2, 2.5 9-10 W 1.1,1.2,1.3, 1.4,1.5, 9-10 2.3a,b,c,d,e,f 9-10 LS 1.7, 2.2a,b,c,d,e,f 11-12 W 1.6,1.8 11-12 LS 1.8		
Castaways Park	B 6b I 1m	9-10 R 2.3, 2.5 9-10 LS 1.1, 1.6, 1.9, 1.12, 1.13, 2.5a,b,c,d 11-12 LS 1.6, 1.8, 1.11, 1.12	D 12.7.5 E 12.1.3	
Seed Experiments	C 5a,d B 6b,e I 1a,b,c,d			PS 6.0
Plant Monitoring	B 6a,b,c,d,e; 8b I 1a,g,j,k	9-10 LS 2.2b,c,f; 2.6c 11-12 LS 1.8		PS 8.0
Wetlands Tradeoffs	B 6b	9-10 R 2.3, 2.5, 2.8 9-10 W 1.3, 1.5 9-10 LS 1.3, 1.6, 1.8, 2.5a,b,c,d 11-12 R 2.3, 2.4, 2.5, 2.6 11-12 LS 1.2, 1.3, 1.6, 1.8	D 12.7.5 E 12.1.1, 12.1.3, 12.1.4	
Stewardship	B 6a,b	9-10 W 1.1, 2.3b,c,d,e,f; 9-10 2.5a,b,c,d 11-12 R 2.1 11-12 W 1.3, 1.4	D 12.7.5 E 12.1.3	

Science: **C**=Chemistry; **B**=Biology/Life Sciences; **E**=Earth Sciences; **I**=Investigation and Experimentation
English-Language Arts: **R**=Reading; **W**=Writing; **LS**=Listening and Speaking
History/Social Science: **D**=Principles of American Democracy; **E**=Principles of Economics
Mathematics: AI=Algebra I; **PS**=Probability and Statistics